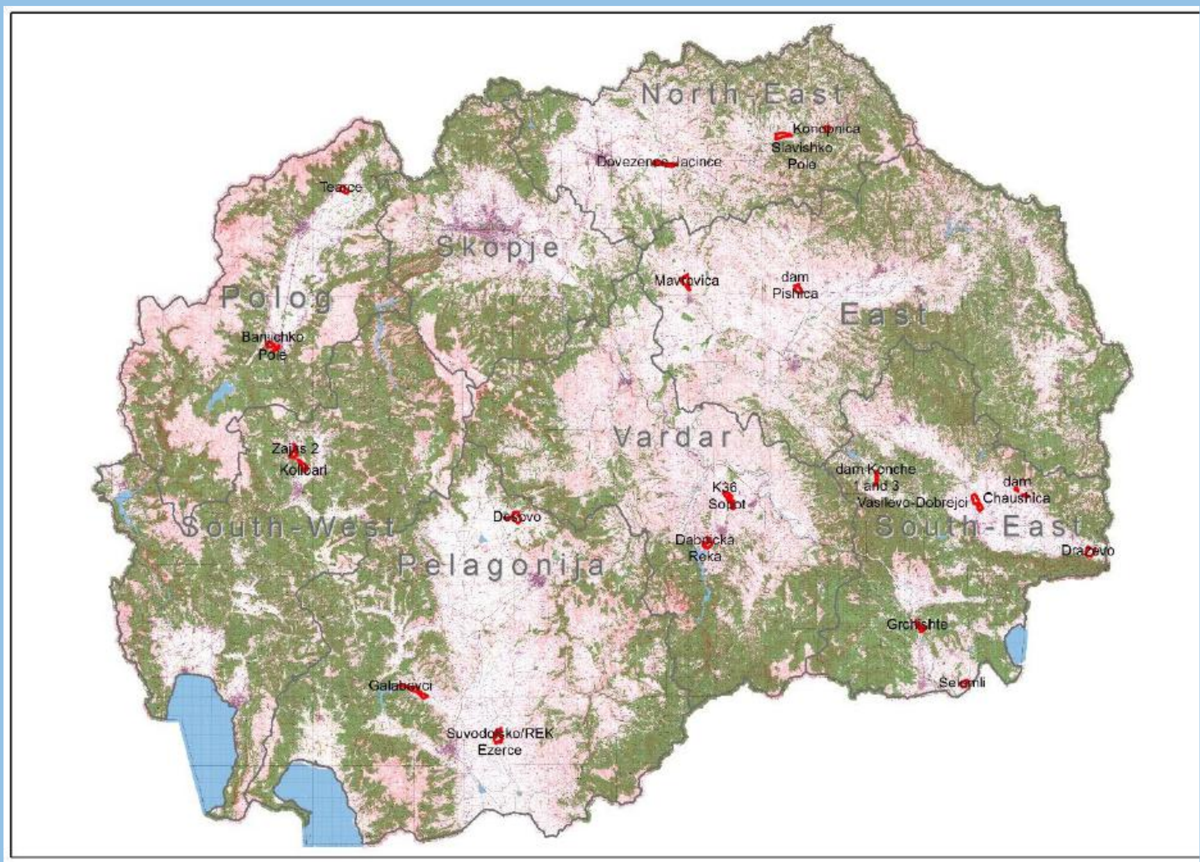
MINISTRY OF AGRICULTURE, FORESTRY AND WATER ECONOMY

Small-scale, low-cost, environment friendly irrigation schemes: sites selection and preparation of full work tender dossier

EuropeAid/137393/DH/SER/MK



PRE-FEASIBILITY Report FINAL

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Project Name:	Small-scale, low-cost, environment friendly irrigation schemes: sites selection and preparation of full work tender dossier
Reference No:	EuropeAid/137393/DH/SER/MK
Contracting Authority:	European Union Delegation
Beneficiary:	Ministry of Agriculture, Forestry and Water Economy (MAFWE)
Consultant:	Consortium: Eptisa – Temelsu – PointPro
Report:	PRE-FEASIBILITY Report Version 3

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LIST OF ABBREVIATIONS

Abbreviation	Full Text
BCR	Benefit Cost Ratio
BoQ	Bill of Quantities
CAD	Computer Aided Design
CF	Conversion factor
DEM	Digital Elevation Model
DSM	Digital Soil Mapping
DJK	Dovezence – Jachince – Klechovce
EIA	Environmental Impact Assessment
EIRR	Expected internal rate of return
ENPV / NPV	Expected net present value / Net present value
EU	European Union
ETO	Evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GDP	Gross Domestic Product
GIS	Geographical Information System
GSM	General Circulation Models
Ha	Hectare
HDPE	High-density polyethylene pipes
HEC	Hydrological Engineering Centre
HPP	Hydro Power Plant
ICID	International Commission on Irrigation and Drainage
IPA	Instruments for Pre-Accession Assistance
IPARD	Instrument for Pre-Accession Assistance in Rural Development
IRR	Irrigation
IWR	Irrigation Water Requirement
JICA	Japan International Cooperation Agency
JSCWM	Joint Stock Company for Water Management
LPIS	Land Parcel Identification System
MAFWE	Ministry of Agriculture, Forestry and Water Economy
MS	Meteorological Station
MASIS	Macedonian Soil Information System
Masl	Meters above sea level
Max	Maximum
Mkd	Macedonian denar currency
Mm / Mm3	Millimetres / Million meters cubic
MoEPP	Ministry of Environment and Physical Planning
MoU	Memorandum of Understanding
N	Nitrogen
NPK	Nitrogen, Phosphorus and Potassium (seeds fertilizer)
OM	Organic meter
O&M	Operation and maintenance
PVC	Polymerizing Vinyl Chloride
P/Peff	Precipitation/ Effective Precipitation
RC/RCP	Reinforced Concrete Pipes
SR	Solar radiation
SSORM	State Statistical Office of Republic of Macedonia
T	Temperature
ToR	Terms of Reference
UR	Unemployment rate
VAT	Value added tax
WME	Water Management Enterprise
WS	Wind speed

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Reference No:	EuropeAid/137393/DH/SER/MK		
Project Duration	28 months		
Project Start Date	4th September 2017		
Project End Date	4th January 2020		
	Contracting Authority	**Beneficiary**	**Consultant**
Name	Delegation of the European Union	Ministry of Agricultural, Forestry and Water Economy	Consortium: Eptisa, Temelsu, PointPro
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Key Stakeholders and Target Groups:	Target group	The main target groups are the farming communities whose lands will be provided with access to irrigation facilities.	
	Beneficiaries	Ministry of Agriculture, Forestry and Water Economy (MAFWE), Joint Stock Company for Water Management (AD Vodostopanstvo), Municipalities and farmers organisations	

Project's Results:	Result 1	Potential irrigation project sites to be identified, project sites to be surveyed and prefeasibility report to be prepared (at least 15-20 potential sites to be assessed).
	Result 2	Feasibility studies to be prepared (at least 6-8 feasibility studies).
	Result 3	Detailed Technical designs of environmentally and economically efficient community based small scale irrigation scheme to be prepared and tender dossiers compiled (6- 8 sites).
	Result 4	Farmer groups established on each of the irrigation investment project site for which tender dossiers to be prepared (6-8 farmers groups). Farmers to be trained and capable to manage the small-scale irrigation scheme.
	Result 5	Methodology for calculation of irrigation water tariff to be developed to achieve sustainability of community-based, small-scale irrigation systems managed by water users.

1 EXECUTIVE SUMMARY

1.1 PREVIOUS SCREENING PHASE ACTIVITIES

IDENTIFICATION OF SUITABLE IRRIGATION AREAS (POOL OF 200 SCHEMES) BASED ON THE ANALYTICAL HIERARCHY PROCESS

During the Screening Phase, a pool of 201 sites has been identified based on information available from different sources:

1. Plan of Activities of the Water Management Directorate 2015-2025, MAFWE, Skopje December 2014;
2. Terms of Reference of this project;
3. Study on small reservoir dams, MAFWE, 1984;
4. Pre-Feasibility study of irrigation sites done by DSI Turkey, 2017;
5. Other sources as Municipalities' plans, and Consultant´s documentation;
6. Interviews with Authorities of the Joint Stock Company for Water Management branches;
7. Interviews with Municipal representatives;
8. Field visits.

The complete list of 201 identified sites can be found as Annex 1 of the Screening Report, organized by eight planning regions: East, North-East, Pelagonija, Polog, Skopje, South-East, South-West and Vardar. For easier follow up list is attached to this summary.

The applied methodology for selecting suitable locations for building new or restoration of the existing irrigation scheme in the country was based on a combination of Geographic Information System (GIS) and Analytical Hierarchical Process (AHP) and consists of the following steps:

1. Defining the Problem;
2. Identification of key experts and stakeholders in the decision-making process and the definition of criteria for assessing the location suitability;
3. The collection and preparation of data (digitization, statistical analysis, etc.) and creation of raster data for each factor;
4. Classification of data sets and forming the suitability map for each factor (criterion limit);
5. Establishment of a preference matrix, assigning preference values to the relevant criteria using Saaty's scale;
6. Calculation of weighted factors of the criteria; the factors that have been identified as crucial are grouped into four basic factor groups:
   - **Socio-economic:** Farmer density (per ha), Distance from markets (km), Unemployment rate, Income (per ha);
   - **Climate:** Potential Evapotranspiration Eto (mm), Precipitation (mm), Climate change (temperature ˚C);
   - **Geo-morphological**: Slope (°), Elevation (m), Aspect;
   - **Geo-natural**: Distance from intake (m), Soil characteristics (texture), Erosion.
7. Weighting of maps by means of AHP and their summing up in the map of suitability: *AHP is a widely accepted decision-making method which is used to determine the relative importance of the criteria in a specified decision-making problem based on pairwise comparisons. (Saaty,1980).*
8. Creation of map-factors constraints;
9. Calculating the result raster (final suitability map) as a weighted summation of all criteria raster data sets and applying constrain mask.

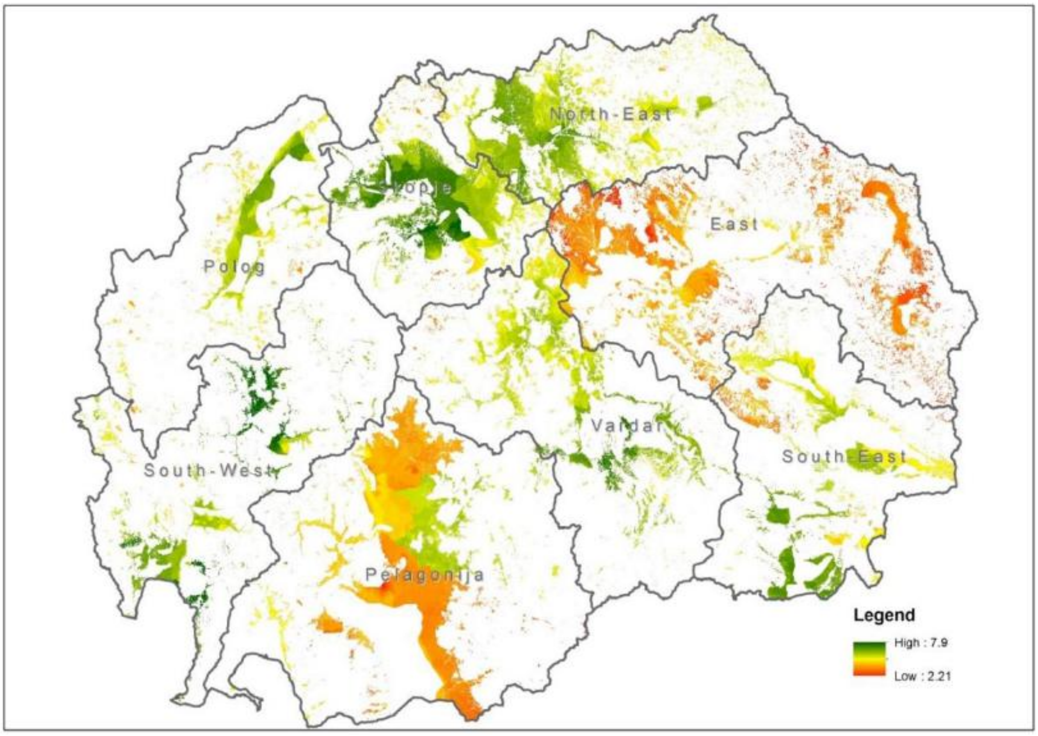

Figure 1. Suitability map of possible sites

FURTHER SELECTION PROCESS

SELECTION OF 85 SITES

A list of 85 pre-selected sites for further preliminary assessment has been developed (Listed in Annex 2 of the Screening Report) based on criteria given in the Terms of Reference (ToR) and criteria consulted and agreed with Beneficiary. List is attached to this document for easier follow up.

ToR criteria:

1) Mitigation of adverse effects of climate change in agriculture (from project title).
2) The proposed scheme should not be in the framework of the large hydro-melioration scheme.
3) The proposed scheme should be community-based.
4) The proposed scheme should be with one to several villages (in one Municipality).
5) Agriculture land area to be irrigated is <300ha.
6) Agriculture land area is cultivated and critical mass of farmers representing more than 50% of the (potentially) irrigated agriculture area is willing to benefit from investments in small scale systems and take responsibilities to manage it.
7) Quality and maturity of prepared studies and technical documents.

After thorough consultation with MAFWE, a set of further criteria was agreed for further selection of approximately 80 possible locations:

Criteria consulted and agreed with MAFWE:

1) The irrigation area according to the ToR should be less than 300 Ha. It was agreed that the irrigated area in some particular case **can be higher than 300 Ha**, if it is appraised that positive beneficial impacts are from significant importance.

2) The second criterion would be based on **socio economic bases, such us:**
    a. The number of farmers. In existing irrigation schemes, it would correspond to registered farmers at MAFWE, and for new schemes the expected number of beneficiary farmers.
    b. The scheme should be community-based.
    c. Income per hectare.
    d. Unemployment rate.
    e. Expected Internal Rate of Return and Cost Benefit Analysis.

3) The third criterion is that the scheme could be constituted by one to several villages, but **only in one Municipality**;

4) The fourth criterion would be that schemes that involved the construction of a **new dam would be avoided** in most cases, considering there are several existing dams without an irrigated area, and that the construction of a new dam will implicate a high investment compared to the construction of the irrigation scheme in existing dams.

5) The fifth criterion is the **equal distribution across the entire territory of the Republic**.

Water availability was also suggested by the Ministry, but it was difficult to conduct hydrological study for 80 places, so it was left to be evaluated during Pre-Feasibility Study.

It was also stated that a scheme with **high beneficial impact which is not inside the territorial framework of the large hydro-melioration scheme, but related to it (for example, getting water from the LHMS)** should not be excluded from the possible 80 locations, as far as it could **have an independent water management that can be assumed by the farmers, supported with relevant legislation framework.**

Only 3 locations had already prepared studies and technical documents: Grchiste, Vasilievo-Dobrejci and Tearce, and they should be revised anyhow. Thus, this criterion is not fundamental for deciding among projects.

As described in the Screening Report, 24 technical visits were carried out to gather more information about the 85 selected sites. On every field visit, multiple possible sites were evaluated. In this stage in general farmers were not contacted yet, to avoid arising expectations in locations that were not likely to be selected. After desk review of the available data, 22 locations were chosen for on-field detailed visits with the participation of farmers.

SELECTION OF 20 SITES

22 meetings with farmers on the preselected sites were performed as described in the Screening Report.

Based on the information obtained from data available, site visits and interviews with farmers, 20 irrigation projects were selected. The Consultant undertook several site investigations to assure that the 20 potential sites are eligible in terms of fulfilling the criteria given in the ToR and then proposed as the result of the Screening Report to be studied at pre-feasibility level.

The report was approved by the contracting authority on the 16/10/17 and the preparation of pre-feasibility studies began under a tight schedule, because the pre-feasibility studies should be ready after the end of the 3-month inception phase.

1.2 PRE-FEASIBILITY STUDIES

The Pre-Feasibility Report presents a preliminary study undertaken to determine if it would be worthwhile to proceed to the feasibility study stage for the identified small-scale irrigation schemes and to facilitate Contracting Authority and Final Beneficiary with sufficient data for identification of investments.

Pre-feasibility report needs to be reviewed by the Steering Committee of the Project and agreed with MAFWE, the most viable 6-8 locations need to be chosen prior to commencement of Component 1 activities - Feasibility studies, detailed technical designs and tender documents, including Bill of Quantities for the selected small-scale irrigation schemes as well as activities related with Component 2.

The table below gives an overview of the locations identified with the Screening Report, subject of the Pre – Feasibility Report. For each of these sites, a Pre-Feasibility Study was developed and is included as Annexes 1 to 20 of the Pre-Feasibility Report.

Table 1-1 Locations for which Pre-Feasibility Studies were developed

No.	Location	Municipality	Planning Region
1	Zajas	Kichevo	South-West
2	Kolibari	Kichevo	South-West
3	Slavishko Pole	Rankovce	North-East
4	Dovezence-Jachince-Klechovce	Kumanovo	North-East
5	Konopnica	Kriva Palanka	North-East
6	Mavrovica dam	Sveti Nikole	East region
7	Pishica dam	Probishtip	East region
8	Selemli dam	Bogdanci	South East
9	Grchishte	Valandovo	South East
10	Chaushliska dam	Bosilovo	South East
11	Drazhevo	Novo Selo	South East
12	Vasilevo-Dobrejci	Vasilevo	South East
13	Konche 3 and 1 dams	Konche	South East
14	K36	Kavadarci	Vardar
15	Dabnichka reka	Kavadarci	Vardar

16	Suvodolsko	Novaci	Pelagonija
17	Gabalavci	Bitola	Pelagonija
18	Desovo	Dolneni	Pelagonija
19	Tearce	Tearce	Polog
20	Banjichko Pole	Gostivar	Polog

The Pre-Feasibility Report contains a description of the Methodology that was used in each of the Pre-Feasibility studies, for each of the locations, starting with information and description of the project areas; climate, water and land resources, and existing irrigation structures. Afterwards, the proposed design is explained with the used criteria for the design including the hydraulic calculation methodology. Each Study gives an overview on the: preliminary environmental impact assessment, agricultural economics, project cost estimates, economic and financial, as well as social analysis.

Once all the data is presented, the document gives several options that can be used in order to select the final locations. It also outlines the constraints and implications associated with the locations.

The content of the Pre-Feasibility Studies is the following:

1. Executive Summary;
2. Description of the project area: coordinates, municipality, villages, beneficiaries, number of plots, elevation, water source and management institution, if included in an environmental protected area, degree of effect by climate change, etc.;
3. Climate, water and land resources: climatic data, hydrological modelling, reservoir simulation (if present), crop water requirements, water and soil suitability for irrigation, drainage requirements;
4. Existing structures: description of existing reservoir, intake structure and irrigation system;
5. Proposed design: description of the new irrigation system;
6. Preliminary environmental assessment: positive, neutral and negative impacts identified during project lifetime and impacts expected during the implementation phase;
7. Agricultural economics: farm models and cropping patterns, yields and agricultural income with and without project;
8. Project cost estimates: investments, operation and maintenance costs;
9. Economic and financial analysis: Benefit/cost ratio, Expected Net Present Values and Expected Internal Return Rate. Water fees;
10. Social analysis: Social impact of the project, farmers' interest in the system and taking responsibility in the management of water;
11. Annexes: drawings of the proposed irrigation system.

Table below presents the results of undertaken analysis and findings of the analysis:

Table 1-2 Locations with highest IRR of each zone and degree of fulfilment of TOR's and MAWFE's criteria and other constraints from Pre-Feasibility Study

																						CONSTRAINTS derived from criteria and findings													
																						Original TOR criteria (1)			MAWFE criteria (2)				New findings after PFR (3)						
Pre-feasibility Study Nº	Region	Irrigation System name and Municipality	Design irrig.area	Actual irrig.area	Nr farmers	Sp. agric. production	Specific variable cost	Specific fixed cost	Specific net profit	Total investment cost	Sp. total invest. cost	Total annual O&M cost	Specific ann. O&M cost	Av. ann. econ. benef.	Pr.value proj.benefits	Pr.value proj. Costs	Benefit/Cost Ratio	ENPV	EIRR	Initial Water Tariff	Average Water Tariff	1 Climate Change	2 In Large HMS	3 Community based	7 Cost per hectare	Specif. Agronom. Prod	Av. WaterTariff	Number of farmers	Water available	WMC administr.	Marketing problems	Urban Area	TOTAL CONSTRAINTS	lower constraints per zone	RECOMMENDED LOCATIONS
			ha	ha		Mkd/ha	Mkd/ha	Mkd/ha	Mkd/ha	€	€/ha	€	€/ha	€			-	€	%	Mkd/m3	Mkd/m3														
2	South-West	Kolibari, Kichevo Municipality	160	100	100	176.406	129.418	12.662	34.326	1.246.838	7.793	49.557	310	74.787	1.940.348	1.424.533	1,36	515.815	6,31	3,90	5,00	2			2	2	2	1	1				10		1
1	South-West	Zajas 2, Kichevo Municipality	168	30	100	176.406	129.418	12.662	34.326	1.303.622	7.760	51.947	309	73.493	1.878.000	1.499.159	1,25	378.841	6	3,90	5,00	2			2	2	2	1	0				9	x	
3	North-East	Slavishko Pole, Rankovce Municipality	235	40	250	161.076	117.950	12.051	31.074	1.638.250	6.971	60.198	256	160.831	2.552.021	1.927.458	1,37	624.563	6,14	3,40	4,40	1			1	2	2		0				6	x	2
5	North-East	Konopnica, Kriva Palanka Municipality	70	0	200	220.885	165.336	16.349	39.200	611.226	8.732	26.996	386	40.439	995.545	766.586	1,30	228.959	6,08	5,50	7,00	2			2	1	2		2				9		
4	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	235	30	100	161.076	117.950	12.051	31.074	1.828.889	7.783	81.028	344	105.050	2.591.077	2.179.141	1,19	411.936	5,33	4,90	6,20	1			2	2	2	1	1	1	1		11		8a
7	East	Dam Pishica, Probishtip Municipality	170	70	75	153.131	111.128	11.327	30.676	794.540	4.676	33.493	198	72.484	1.859.476	991.810	1,90	867.666	9,14	2,30	3,00	1				2	1	1	1	1			7	x	3
6	East	Dam Mavrovica, Sveti Nikole Municipality	280	0	300	109.191	75.399	8.066	25.726	3.404.685	12.160	84.439	302	155.073	3.656.714	3.755.316	0,97	-98.602	3,80	2,40	3,00	1	1		2	2	1		0	1			8		
12	South-East	Vasilevo-Dobrejci, Vasilevo Municipality	300	60	300	255.648	187.175	17.022	51.451	1.314.126	4.380	80.657	269	239.422	6.683.709	1.966.497	3,40	4.717.212	15,42	2,90	3,70	1	1				1		2	1			6		
8	South-East	Selemli, Bogdanci Municipality	216	200	20	291.372	220.164	20.495	50.714	1.335.442	6.183	95.996	444	136.447	3.630.868	1.647.948	2,20	1.982.921	10,49	4,10	5,30				1		2	2	2				7		
10	South-East	Chaushliska, Bosilovo Municipality	70	0	200	247.109	183.529	16.603	46.978	463.717	6.625	23.008	323	47.661	1.206.378	606.888	2,00	599.490	9,85	3,30	4,20	1		1	1		2		1				6		4
13	South-East	Dam Konche 3 and 1, Konche Municipality	100	20	70	305.047	229.877	22.113	53.057	916.017	9.160	35.064	351	68.213	1.738.340	1.091.318	1,60	647.022	7,66	3,30	4,20	1			2		2	1	1	1			8		
11	South-East	Drazhevo, Novo Selo Municipality, WELLS ALTER.	200	80	100	280.172	214.146	19.319	46.707	1.500.053	7.500	92.366	462	132.558	2.905.285	2.269.771	1,28	635.514	6,32	3,50	5,90	1			1		2	1	0	1			6		
9	South-East	Grchishte, Valandovo Municipality	150	150	300	249.709	182.123	18.219	49.363	1.274.215	8.459	84.553	564	105.202	2.122.600	1.950.630	1,10	171.970	4,85	5,40	6,90				1		2		2				5	x	
15	Vardar	Dabnicka Reka, Kavadarci Municipality	100	60	100	225.851	153.057	16.313	56.480	697.402	6.340	28.341	258	45.452	1.138.031	850.287	1,34	287.744	6,27	2,90	3,71	1			1		1	1	1	1			6		
14	Vardar	K36/Sopot, Kavadarci Municipality	260	370	200	225.851	153.057	16.313	56.480	1.584.019	6.092	81.065	312	107.432	2.545.503	1.966.895	1,29	578.607	6,11	3,50	4,50	1			1		2		0	1			5	x	5
16	Pelagonija	Suvodolsko, Novaci Municipality	305	400	300	176.792	125.445	11.947	39.400	1.459.132	4.784	50.982	167	174.260	4.921.416	1.671.357	2,90	3.250.059	12,61	1,60	2,10	2				2			0				4	x	6
18	Pelagonija	Desovo, Dolneni Municipality	128	120	100	196.150	136.512	12.658	46.980	788.746	6.162	29.897	234	71.458	1.886.797	934.335	2,00	952.462	9,58	3,50	4,40	2			1	2	2	1	1	1			10	x	8b
17	Pelagonija	Galabavci, Bitola Municipality	272	5	60	182.101	132.441	12.902	36.758	2.078.715	7.642	32.226	266	140.450	3.504.416	2.430.881	1,40	1.073.584	6,82	2,70	3,40	2	1		2	2	1	2	0	1			11		
19	Polog	Tearce, Tearce Municipality	160	30	160	159.620	119.547	11.457	28.616	1.042.831	6.158	37.190	232	57.864	1.453.296	1.233.813	1,19	229.483	5,29	3,20	4,10	2			1	2	2		1				8	x	7
20	Polog	Banjichko Pole, Gostivar Municipality	150	50	150	159.620	119.547	11.457	28.616	1.619.815	9.309	45.903	264	75.976	1.918.887	1.777.874	1,08	141.012	4,55	3,60	4,70	2			2	2	2		0		1	1	10		8c

Criteria 1: Equal distribution, less than 300 ha and farmers' strong willingness criteria not included in the table because all projects fulfil the criteria. Technology is pressurized irrigation network for every project. The use of pumps (or not) is reflected in the water tariff.

Criteria 2: Irrigated area more than 300 ha, dams avoided, belong to one municipality and equal distribution considered without using the ranking criteria. The rest are socio-economic criteria mentioned in general in ToR and MAFWE criteria.

Criteria 3: These criteria were added after the preparation of the Pre-Feasibility Report:

a. Water availability after hydrological analysis
b. WMC after meeting with WMC authorities which do not agree with the formation of WUAs if WMC is already administrating the system
c. Marketing problems additional support needed for these locations, not solved by the project
d. Urban area: to warn about proximity to Urban area of one project.

The ranking was performed according to the following criteria:

1) The projects were classified in 7 different regions[1]: South-West, North-East, East, South-East, Vardar, Pelagonija and Polog, to achieve **equal distribution across national territory**.
2) In each region, the projects were ranked according to decreasing **Expected Internal Rate of Return** (EIRR).
3) Then it was taken into consideration the degree of compliance with the criteria and the related constraints for each project, according to the following weigh table:

Table 1-3 Weighs for each criteria and constraint

Nº farmers	**< 70**	**70< Nº farmer<150**	**>150**
	2	1	0
Climate change	Low	Medium	High
	2	1	0
Part of LHMS	Yes	No	
	1	0	
WMC administration	Yes	No	
	1	0	
Cost per hectare	>7500 €/ha	5000 <€/ha< 7500	< 5000 €/ha
	2	1	0
Specific agronomical production	<200 mkd/ha	250<mkd/ha<200	> 250 mkd/ha
	2	1	0
Water availability	Low	Medium	High
	2	1	0
Community based	No	Yes	
	1	0	
Marketing problems	Yes	No	
	1	0	
Close to urban areas	Yes	No	
	1	0	
Water tariff	> 4 mkd/m3	3<mkd/m3<4	<3 mkd/m3
	2	1	0

4) Decide the most favourable project within each region. As there are 7 regions, one more project is to be chosen to reach the number of 8 projects (considering that according to ToR 6-8 projects are expected to be selected).

[1] Skopje region was eliminated in previous phase, due to high urbanization, existing drainage channels and high level of underground waters

To make a decision of which project to be selected in each area (plus one more to reach the number of 8), it is necessary to take into account both the criteria of the ToR and the criteria agreed with MAWFE. All projects comply the criteria, but the degree of compliance can vary from project to project. The weights considered for each criterion were added in the final column, however some criteria could have more relevance than others. Thus, the weights given to criteria and constraints should not be considered strictly according to the numeric value, but as a notice that a project can be of more interest than another, and due to this reason to be taken into consideration. For example, following the criteria and constraints, projects in each region are analysed and summarized as follows:

South-West	Both **Kolibari** and **Zajas** irrigation projects are very similar. • Kolibari is slightly better in the economic ratios than Zajas, but as it is located on the same river downstream Zajas, the water availability depends on the amount diverted by Zajas. • Both irrigation systems need a pump station, which means that the water tariff will be higher.
North East	**Slavishko Pole** and **Dovezence-Jachince-Klechovce** (DJK) are located on the same river. They must be studied hydrologically in parallel, but they do not belong to the same municipality, so according to the ToR and MAFWE, they cannot be jointed in one project. • **DJK** is located downstream Slavishko Pole, the water availability in DJK depending on the amount of water diverted by Slavishko Pole. • The advantage of **Slavishko Pole** is that there is no need to pump the water, which reduces the operation cost and leads to better economic indicators; • **DJK** need a pump station to provide pressurised irrigation water, which leads to higher costs and higher tariffs. • **Konopnica** has a very limited source of water, also used for water supply.
East	• The **Pishica** dam is being repaired with EU funds, but the irrigation system will not be rehabilitated. This means that the rehabilitation of the dam will increase the safety/prevention of floods to Pishica Village, but not benefit the agricultural production. This is a good reason to select Pishica irrigation system to be rehabilitated, but the water availability is not high; • **Mavrovica** needs the main pipeline of 8 km to be replaced, which leads to very high investment costs.

South East	In this region, the two projects with the best EIRR have relatively high constraints, and no one is clearly better. • **Vasilevo - Dobrejci** is the irrigation system with the best economic indicators but being the last user of the LHMS Vodocha dam means the water availability in this system is heavily dependent on the efficiency of water use by all previous users. That is a constraint to be taken into account, because it does not depend only on the water management inside the system; • The next better one, **Selemli**, is a dam that was constructed by a Combinat that is currently not using the land. If in the future the Combinat land is used, there will be not enough water for both systems: the one proposed now, and the one existing previously; • **Chaushica** dam has a small volume which irrigates a reduced area, which leads to reduced investment costs. Also, after the Pre-Feasiblity study it was found that the amount of water is not enough for one of the villages identified as beneficiary. Thus, 40% of the possible area for irrigation belongs to a private company which can be advantageous for the management of the system, but the ToR criteria states that community-based systems are preferred; • **Konche** has a limited amount of water available, which leads to reduced investment cost; • **Drazhevo** and **Grchishte** need pumping, which leads to lower economic indicators and higher tariff. The second one has a private owner which was not considered in the proposed irrigated area, although he can also benefit from the project.
Vardar	• **K36/Sopot** needs a pump station, which means that the water tariff will be higher compared to the systems with natural pressure; and depends on a LHMS for supply of water. • **Dabnichka Reka** has natural pressure but low water availability, which also means reduced irrigated area and reduced investment costs.
Pelagonija	• **Suvodolsko** irrigation system has natural pressure and high water availability. • **Desovo** has limited water availability, which leads to reduced irrigated area and reduced investment costs. • **Gabalavci** has a small number of farmers compared to other systems and depends on a LHMS for supply of water.
Polog	**Tearce** and **Banjichko Pole** are very similar. • Both locations need long main pipes that run across the village. Both locations have natural water pressure. • Tearce has a lower water availability than Banjichko Pole, while for the area of Banjichko Pole, having in mind the tendencies from last 20 years, there is a likelihood some percentage of the agricultural land to be transformed into an urban area, which is not valid for Tearce (due to the location it has) and has to solve marketing problems.

It is important to note that in the locations with zero risk in water availability, the irrigated area can be increased in the Feasibility Study, if there is no other constraint (available land, etc.). This could be a solution for utilization of the available funds, while on the other side, increasing the area chosen for the irrigation systems will increase the number of farmers who will benefit as end users.

Following the obtained ranking, based on the following criteria:

1) **Equal distribution across national territory:** at least one project of each region
2) **Higher Expected Internal Rate of Return** (**in each region)**,

the final projects considered by the Consultant as most preferable are:

South-West	**Kolibari** and **Zajas** could be considered as one location, but this will cause almost 3 million € to be located in only one location, reason for which this will be considered separately. **Kolibari** has slightly better indicators than Zayas, so is the first to be considered in this region.
North East	**Slavishko Pole,** not needing pumps, is more environmentally friendly and has better economic and financial performance than **Dovezence-Jachince-Klechovce** (DJK). As they are using the same river as source of water, they should be considered hydrologically as one project, but they belong to different municipalities. **DJK** has high social interest to be developed, because many are poor farmers even without water, although several plots that belong to people who does not reside in the location were identified. DJK is proposed to be considered as the second project in this region.
East	The **Pishica** dam is being repaired, thus it is good reason to provide a new irrigation system to use the rehabilitated infrastructure, but the water availability is not high.
South East	In this region, the two projects with best EIRR have relatively high constraints. The consultant suggests choosing the third one, **Chaushica** dam although 40% of the area belongs to a private company, which can be an advantage for the management of the system.
Vardar	In this region, both projects have some constraints: **K36/Sopot** depends on Tikvesh HMS and **Dabnichka reka** has low water availability. **K36/Sopot** is considered preferable for this region.
Pelagonija	In this region **Suvodolsko** irrigation system has natural pressure **and** high-water availability and the highest EIRR of all, therefore is considered the most preferable location.
Polog	Tearce and Banjichko Pole are very similar. Tearce has better economic indicators, and Banjichko Pole has more water available, urban proximity and marketing problems. **Tearce** is preferred, but **Banjichko Pole** is recommended as the second project for this area

There are three regions where two projects have been proposed in each region: Polog, North East and South East. The reason for proposing more than one project in this region is:

- These three regions have the lowest GDP (Makstat, 2017)
    - Polog 121.824 MKD/capita in 2015
    - Northeast 164 161 MKD/capita in 2015
    - Southeast 212 913 MKD/capita in 2015
    - The national average is 269.966 MKD/capita in 2015

PREFERABLE IRRIGATION SITES - RECOMMENDED FOR NEXT PHASE

Therefore, based on the above mentioned, the Consultant considers the following irrigation locations as preferable to be developed at Feasibility Level:

1) **Kolibari**
2) **Slavishko Pole**
3) **Pishica**
4) **Chaushica**
5) **K36/Sopot**
6) **Suvodolsko**
7) **Tearce**
8) **Banjichko Pole**

The ToR requires 6 to 8 locations to be developed at Feasibility level. In case some of the locations during Feasibility phase shows a high constraint that has not been identified during Pre-feasibility study the next in ranking will be **Zajas** and **Dovezonce-Jaznice-Klecevce.**

LESS PREFERABLE SITES

The not recommended sites and the main reason for that are:

The sites less preferable according to the Consultant and the main reasons for that, are:

- **Konopnica**: too little water, in competition with water supply. Only 70ha for irrigation possible, in the best situation.
- **Mavrovica**: too high investment cost (3.4 Million € for 280 ha).
- **Vasilievo-Dobrejci**: last user of Vodocha dam. Depends on the efficient water use upstream.
- **Selemli**: future possible water conflict with the Combinat. Low number of farmers.
- **Konche**: little water available from different sources, just 100 potential hectares.
- **Drazhevo**: high pumping costs, high water tariff.
- **Grchiste**: high pumping costs, high water tariff. Water is now available at 6 m depth in every plot.
- **Dabnichka recka**: low water availability.
- **Gabalavci**: low number of farmers with bigger plots.
- **Desovo**: reduced water availability, which will not be increased by the project (only by the increment in the water efficiencies). Farmers prefer dam option, which is too expensive for actual funding available.

Table 1-4 Table of preferable locations, recommended for proceeding into Feasibility Stage (8 locations plus 2 backup locations)

	Region	Irrigation System name and Municipality	Design irrigated area	Actual irrigated area	Total arable area	Nr farmers	Sp. agric. production	Specific variable cost	Specific fixed cost	Specific net profit	Total investment cost	Sp. total invest. cost	Total annual O&M cost	Specific ann. O&M cost	Av. ann. econ. benef.	Pr.value proj.benefits	Pr.value proj. Costs	Benefit/Cost Ratio	ENPV	EIRR	Initial Water Tariff	Average Water Tariff
			ha	ha	ha		Mkd/ha	Mkd/ha	Mkd/ha	Mkd/ha	€	€/ha	€	€/ha	€	€	€	-	€	%	Mkd/m3	Mkd/m3
1	South-West	Kolibari, Kichevo Municipality	160	100	524	100	176.406	129.418	12.662	34.326	1.246.838	7.793	49.557	310	74.787	1.940.348	1.424.533	1,36	515.815	6,31	3,90	5,00
2	South-West	Zajas 2, Kichevo Municipality	168	30	691	100	176.406	129.418	12.662	34.326	1.303.622	7.760	51.947	309	73.493	1.878.000	1.499.159	1,25	378.841	6	3,90	5,00
3	North-East	Slavishko Pole, Rankovce Municipality	235	40	1.060	250	161.076	117.950	12.051	31.074	1.638.250	6.971	60.198	256	160.831	2.552.021	1.927.458	1,37	624.563	6,14	3,40	4,40
4	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	235	30	2.592	100	161.076	117.950	12.051	31.074	1.828.889	7.783	81.028	344	105.050	2.591.077	2.179.141	1,19	411.936	5,33	4,90	6,20
5	East	Dam Pishica, Probishtip Municipality	170	70	641	75	153.131	111.128	11.327	30.676	794.540	4.676	33.493	198	72.484	1.859.476	991.810	1,90	867.666	9,14	2,30	3,00
6	South-East	Chaushliska, Bosilovo Municipality	70	0	980	200	247.109	183.529	16.603	46.978	463.717	6.625	23.008	323	47.661	1.206.378	606.888	2,00	599.490	9,85	3,30	4,20
7	Vardar	K36/Sopot, Kavadarci Municipality	260	40	1.785	200	225.851	153.057	16.313	56.480	1.584.019	6.092	81.065	312	107.432	2.545.503	1.966.895	1,29	578.607	6,11	3,50	4,50
8	Pelagonija	Suvodolsko, Novaci Municipality	305	150	1.867	300	176.792	125.445	11.947	39.400	1.459.132	4.784	50.982	167	174.260	4.921.416	1.671.357	2,90	3.250.059	12,61	1,60	2,10
9	Polog	Tearce, Tearce Municipality	160	30	1.061	160	159.620	119.547	11.457	28.616	1.042.831	6.158	37.190	232	57.864	1.453.296	1.233.813	1,19	229.483	5,29	3,20	4,10
10	Polog	Banjichko Pole, Gostivar Municipality	150	50	594	150	159.620	119.547	11.457	28.616	1.619.815	9.309	45.903	264	75.976	1.918.887	1.777.874	1,08	141.012	4,55	3,60	4,70

Relevant indicators chosen to measure the benefits of each location

Table 1-5 Table of less preferable locations, not recommended for entering into the Feasibility Stage

Nº	Region	Irrigation System name and Municipality	Design irrig.area	Actual irrig.area	Nr farmers	Sp. agric. production	Total investment cost	Benefit/Cost Ratio	ENPV	EIRR	Average Water Tariff	Main reason for exclusion
			ha	ha		Mkd/ha	€	-	€	%	Mkd/m3	
1	North-East	Konopnica, Kriva Palanka Municipality	70	0	200	220.885	611.226	1,30	228.959	6,08	7,00	too little water, in competition with water supply. Only 70 ha possible in the best situation.
2	East	Dam Mavrovica, Sveti Nikole Municipality	280	0	300	109.191	3.404.685	0,97	-98.602	3,80	3,00	too high investment cost
3	South-East	Vasilevo-Dobrejci, Vasilevo Municipality	300	60	300	255.648	1.314.126	3,40	4.717.212	15,42	3,70	last user of Vodocha dam. Depends on the efficient use upstream.
4	South-East	Selemli, Bogdanci Municipality	216	200	20	291.372	1.335.442	2,20	1.982.921	10,49	5,30	future water conflict with Combinat. Low number of farmers
5	South-East	Dam Konche 3 and 1, Konche Municipality	100	20	70	305.047	916.017	1,60	647.022	7,66	4,20	little water available from different sources, just 100 ha
6	South-East	Drazhevo, Novo Selo Municipality, WELLS ALTER.	200	80	100	280.172	1.500.053	1,28	635.514	6,32	5,90	high pumping costs, high water tariff. Farmers wants dams alterantive
7	South-East	Grchishte, Valandovo Municipality	150	150	300	249.709	1.274.215	1,10	171.970	4,85	6,90	high pumping costs, high water tariff. Water is now available at 6 m deph in every plot.
8	Vardar	Dabnicka Reka, Kavadarci Municipality	100	60	100	225.851	697.402	1,34	287.744	6,27	3,71	low water availability.
9	Pelagonija	Galabavci, Bitola Municipality	272	5	60	182.101	2.078.715	1,40	1.073.584	6,82	3,40	low number of farmers with bigger plots.
10	Pelagonija	Desovo, Dolneni Municipality	128	120	100	182.123	788.746	2,00	952.462	9,58	3,50	low water availability. Farmers wants dams alterantive

1.3 FINAL RECOMMENDATIONS

The ToR establishes the bases for recommendation of priority investment sites justified by:

1) **The type of technology** of irrigation infrastructure (low-cost and environmentally friendly);
2) **Strong willingness** of water users to cooperate in managing the scheme further expressed in MoU or notary statements of farmers group;
3) **Socio-economic and gender aspects** shall be considered as well;
4) The selection of priority investment sites will be also on the basis of **available funding of the investment under IPA II (in particular IPA II 2015**) and/or other funding options through IFI's, national budget, etc.

Selection of priority investment sites should be done based on importance of benefits of each location measured by relevant indicators.

The 10 locations recommended for preparation of feasibility study are going to be evaluated once more time with the same methodology used to rank the final 10 in order to prioritise its funding. In this case, instead of the constraints (to eliminate the projects with more constraints), the ranking will be performed define the more preferable projects. The criteria to be used will be

- **Low cost**:
  - the specific total investment cost (€/ha) will reflect lowest investment needed.
  - The initial water tariff (MKD/m3) will reflect economic sustainability for farmers.
- **Environmental friendly**: all systems are pressurized piped systems to increase the conduction and applications efficiencies, thus protecting the water resource. Systems that will not require pumping will be preferred.
- **Strong willingness of farmers** will not be considered because the 20 projects evaluated at pre-feasibility level have high interest from farmers. Projects were farmers were not willing to participate were already cleared from the list.
- **Socio-economic and gender aspects:** in this case, B/C ratio, the increase of the irrigated area (from actual to designed) and the percentage of irrigated area design in the irrigation system related to the total arable area in the village or villages will be used as indicators. Gender aspects were not specifically considered, because even in locations with patriarchal surrounding women will surely benefit from the irrigation system as with the rise of the economic development, the independency and access to education.

Table 1-6 Weights for each criterion

Cost per hectare	>7500 €/ha	5000 - 7500 €/ha	< 5000 €/ha
	2	1	0
Initial water tariff	>2,5 mkd/m3	3,20 – 3,50 mkd/m3	<3,20 mkd/m3
	2	1	0
Environmental Friendly	Pumping	No pumping	
	1	0	
B/C ratio	<1,5	1,5 – 2	>2
	2	1	0
Increase of irrigated area	<250%	250-500%	>500%
	2	1	0
	≤ 15%	15 - 25%	>25%

Percentage of irrigated area to total arable area	2	1	0

According to the weight in points given to each criterion, the projects with lower scores will be the best ranked.

The application of this criteria leads to the results shown in table 1-7.

1) **Suvodolsko**
2) **Pishica**
3) **Chaushliska**
4) **Slavishko Pole**
5) **K36/Sopot**
6) **Tearce**
7) **Banjichko Pole**
8) **Kolibari**
9) **Zajas 2**
10) **Dovezence-Jachince-Klechovce (DJK)**

In order to determine the locations in order of priority with equal distribution in the territory, the following criteria was applied:

- Respect the order of the weight points obtained by each location;
- Avoid choosing two locations in the same area. First the best location was to be chosen, then the second:
    - The first five locations ranked belongs to different areas, there was no need to modify the order.
    - Sixth and seven (Tearce and Banjichko Pole) are in the same region (Polog). Kolibari and Zayas 2) are in the same region South-West. Both have the same weight according to the benefit criteria. Then, comparing the figures for both systems, Tearce has lower total and specific (per hectare) investment cost, operation and maintenance costs, which leads to better B/C ratio and lower water tariff. Tearce is ranked in sixth place, and then it is necessary to incorporate the following system from another area, thus the choosing must be performed between Kolibari and Zajas 2. Both have the same weight according to benefit criteria. Comparing both, Kolibari has less investment cost and similar benefits, which leads to a higher ratio Benefit/Cost. Kolibari will occupy the seven positions.
    - As Banjichko Pole has more weigh in the benefit criteria, it will be the eight project.
    - The last two locations will be left as alternatives in case during Feasibility Study some location has some important constraints not foreseen during pre-feasibility phase. They are Zajas 2 and DJK. Comparing both, DJK has the highest total and specific (per hectare) investment cost, operation and maintenance costs, which leads to lower B/C ratio and higher water tariff. DJK is left in the lowest priority for funding of the preferable sites.

The locations in order of priority with equal distribution in the territory are:

1) **Suvodolsko**
2) **Pishica**
3) **Chaushliska**
4) **Slavishko Pole**
5) **K36/Sopot**
6) **Tearce**
7) **Kolibari**
8) **Banjichko Pole**

And in case during Feasibility Studies one of the previous ones is not Feasible, there are 2 backup locations identified:

a. **Zajas 2**
b. **Dovezence-Jachince-Klechovce (DJK),**

Table 1-7 Application of ranking criteria for prioritization of investment

	Region	Irrigation System name and Municipality	Specific investment cost €/ha		Initial Water Tariff mkd/m3		Environmetal friendly		Benefit/Cost ratio		Increase of irrigated area %		Irrigated/total arable area %		TOTAL
			€/ha	weight points	mkd/m3	weight points	[-]	weight points	[-]	weight points	%	weight points	%	weight points	weight points
1	Pelagonija	Suvodolsko, Novaci Municipality	4.784	0	1,60	0	No pump	0	2,90	0	103%	2	16%	1	**3,00**
2	East	Dam Pishica, Probishtip Municipality	4.676	0	2,30	0	No pump	0	1,90	1	143%	2	27%	0	**3,00**
3	South-East	Chaushliska, Bosilovo Municipality	6.625	1	3,30	1	No pump	0	2,00	1	700%	0	7%	2	**5,00**
4	North-East	Slavishko Pole, Rankovce Municipality	6.971	1	3,40	1	No pump	0	1,37	2	488%	1	23%	1	**6,00**
5	Vardar	K36/Sopot, Kavadarci Municipality	6.092	1	3,50	1	Pump	1	1,29	2	550%	0	15%	1	**6,00**
6	Polog	Tearce, Tearce Municipality	6.158	1	3,50	1	No pump	0	1,19	2	433%	1	15%	1	**6,00**
7	Polog	Banjichko Pole, Gostivar Municipality	9.309	2	3,20	0	No pump	0	1,08	2	200%	2	25%	0	**6,00**
8	South-West	Kolibari, Kichevo Municipality	7.793	2	3,90	2	Pump	1	1,36	2	60%	2	31%	0	**9,00**
9	South-West	Zajas 2, Kichevo Municipality	7.760	2	3,90	2	Pump	1	1,25	2	460%	1	23%	1	**9,00**
10	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	7.783	2	4,90	2	Pump	1	1,19	2	683%	0	9%	2	**9,00**

Table 1-8 Order of priority for investments with equal distribution

Priority with equal distribution	Region	Irrigation System name and Municipality	Design irrigated area	Actual irrigated area	Total arable area	Nr farmers	Sp. agric. production	Specific variable cost	Specific fixed cost	Specific net profit	Total investment cost	Sp. total invest. cost	Total annual O&M cost	Specific ann. O&M cost	Av. ann. econ. benef.	Pr.value proj.benefits	Pr.value proj. Costs	Benefit/Cost Ratio	ENPV	EIRR	Initial Water Tariff	Average Water Tariff
Nr			ha	ha	ha		Mkd/ha	Mkd/ha	Mkd/ha	Mkd/ha	€	€/ha	€	€/ha	€	€	€	-	€	%	Mkd/m3	Mkd/m3
1	Pelagonija	Suvodolsko, Novaci Municipality	305	150	1.867	300	176.792	125.445	11.947	39.400	1.459.132	4.784	50.982	167	174.260	4.921.416	1.671.357	2,90	3.250.059	12,61	1,60	2,10
2	East	Dam Pishica, Probishtip Municipality	170	70	641	75	153.131	111.128	11.327	30.676	794.540	4.676	33.493	198	72.484	1.859.476	991.810	1,90	867.666	9,14	2,30	3,00
3	South-East	Chaushliska, Bosilovo Municipality	70	0	980	200	247.109	183.529	16.603	46.978	463.717	6.625	23.008	323	47.661	1.206.378	606.888	2,00	599.490	9,85	3,30	4,20
4	North-East	Slavishko Pole, Rankovce Municipality	235	40	1.060	250	161.076	117.950	12.051	31.074	1.638.250	6.971	60.198	256	160.831	2.552.021	1.927.458	1,37	624.563	6,14	3,40	4,40
5	Vardar	K36/Sopot, Kavadarci Municipality	260	40	1.785	200	225.851	153.057	16.313	56.480	1.584.019	6.092	81.065	312	107.432	2.545.503	1.966.895	1,29	578.607	6,11	3,50	4,50
6	Polog	Tearce, Tearce Municipality	160	30	1.061	160	159.620	119.547	11.457	28.616	1.042.831	6.158	37.190	232	57.864	1.453.296	1.233.813	1,19	229.483	5,29	3,20	4,10
7	South-West	Kolibari, Kichevo Municipality	160	100	524	100	176.406	129.418	12.662	34.326	1.246.838	7.793	49.557	310	74.787	1.940.348	1.424.533	1,36	515.815	6,31	3,90	5,00
8a	Polog	Banjichko Pole, Gostivar Municipality	150	50	594	150	159.620	119.547	11.457	28.616	1.619.815	9.309	45.903	264	75.976	1.918.887	1.777.874	1,08	141.012	4,55	3,60	4,70
8b	South-West	Zajas 2, Kichevo Municipality	168	30	691	100	176.406	129.418	12.662	34.326	1.303.622	7.760	51.947	309	73.493	1.878.000	1.499.159	1,25	378.841	6	3,90	5,00
8c	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	235	30	2.592	100	161.076	117.950	12.051	31.074	1.828.889	7.783	81.028	344	105.050	2.591.077	2.179.141	1,19	411.936	5,33	4,90	6,20

The foreseen sources of funding are:

1) INSTRUMENT FOR PRE-ACCESSION ASSISTANCE 2014-2020 (IPAII,2014): According to the ToR and the Consultant`s perception based on the expenditure of the Budget of EU contribution, it is expected that the available funding for contracting will be:
    a. 2019: 3.000.000 €
    b. 2021: 3.000.000 €

2) NATIONAL BUDGET OF THE REPUBLIC OF MACEDONIA: according to the 2015-2025 Activities' plan of Directorate for Water Management of MAFWE, (MAFWE,2015) the available funding for public irrigation infrastructure to be contracted will be:
    a. 2020: 3.000.000 €
    b. 2022: 1.600.000 €

Based on these assumptions, the consultant is proposing the following financing scenario:

Table 1-9 Timeline for funding

			Year contracting	2019	2020	2021	2022
			IPA II	3.000.000		3.000.000	
			MAFWE		3.000.000		1.600.000
			Tot.financ.€	3.000.000	3.000.000	3.000.000	1.600.000
	Region	Irrigation System name and Municipality	Tot.invest.€				
1	Pelagonija	Suvodolsko, Novaci Municipality	1.459.132		1.459.132		
2	East	Dam Pishica, Probishtip Municipality	794.540	794.540			
3	South-East	Chaushliska, Bosilovo Municipality	463.717	463.717			
4	North-East	Slavishko Pole, Rankovce Municipality	1.638.250	1.638.250			
5	Polog	Tearce, Tearce Municipality	1.042.831			1.042.831	
6	Vardar	K36/Sopot, Kavadarci Municipality	1.584.019		1.584.019		
7	South-West	Kolibari, Kichevo Municipality	1.246.838			1.246.838	
8a	Polog	Banjichko Pole, Gostivar Municipality	1.619.815				1.619.815
			9.849.142	2.896.507	3.043.151	2.289.669	1.619.815
			Acumulated	2.896.507	5.939.658	8.229.327	9.849.142

According to the 2015-2025 Activities' plan of Directorate for Water Management of MAFWE, there will be allocated funds for Suvodolsko irrigation system in 2020.

Taking this into consideration, the consultant recommends being financed within the 3 million € programmed under IPA II 2015 the three best projects, following Suvodolsko, which has funds allocated for the next year:

- Pishica 794.540 €
- Chaushliska 463.717 €
- Slavishko Pole 1.638,250 €

In the second year (2020) they should be contracted Suvodolsko (1.459.132 €) and Tearce (1.042.831 €), but the cost of these two systems (2.501.963 €) will be less than the available funds, so the consultant recommends to contract in 2020:

- Suvodolsko 1.459.132 €
- K36/Sopot 1.584.019 €

Which sum up to 3.043.151€, matching the available funding.

In the third year (2021) they should be contracted Tearce (1.042.831 €) and Kolibari (1.246.838 €), which amount together 2.289.669, less than the 3 million available, but the 710.331€ remaining will not be enough for the last project Banjichko Pole, 1.619.815 €, that will have to wait until 2022 to be contracted.

2 METHODOLOGY FOR PREPARATION OF PRE-FEASIBILITY STUDIES

2.1 DESCRIPTION OF THE PROJECT AREA

A table with a short description of the representative data and the present situation of the irrigation scheme in each project was prepared as the first identification level. It was based on cartographic data (AREC-JICA, 2009, 1:25.000 scale):

- Municipality where the irrigation area is located;
- Coordinates;
- Elevation;
- Irrigation area slope: (in %);
- Number of plots;
- Average farm size.

The villages were farmers live and the actual irrigation area were taken from the Screening Report, based on the data collected during meetings with farmers.

The population of the villages was taken from the Census of Population, Households and Dwellings 2002. State Statistical Office of the Republic of Macedonia, 2002 (SSORM, 2002).

The information regarding the water management institution and whether the system is included in a larger scheme was obtained during meetings with authorities or personnel of the Joint Stock Company "Water Management of the Republic of Macedonia" (JSCWM), or meetings with farmers.

The information about the environmental status (whether the system is in a protected area) was checked from the Ministry of Environment and Physical Planning – Designated areas.

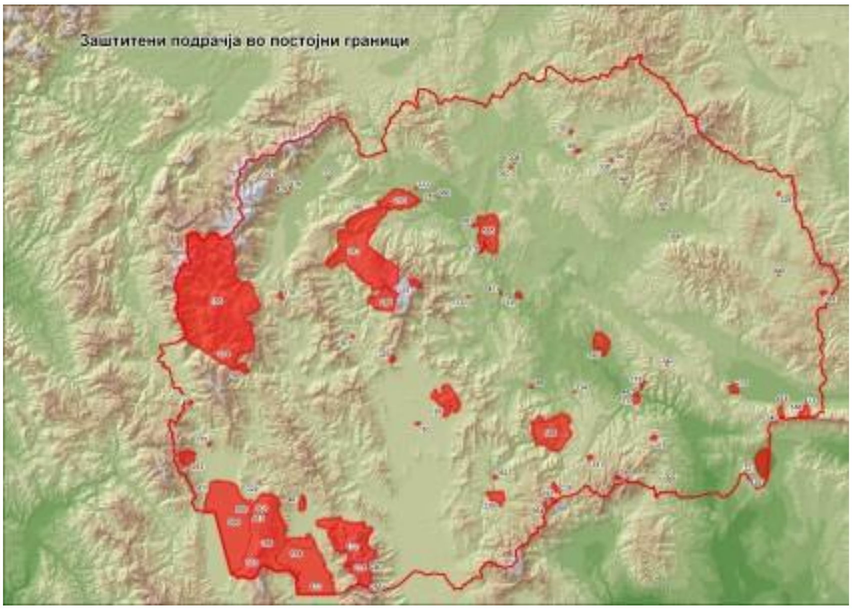

Figure 2-1 Protected areas in R. Macedonia

The water source and the characterization if the water availability is high, medium or low were obtained from the hydrological analysis performed in the prefeasibility study.

2.2 CLIMATE, WATER AND LAND RESOURCES

CLIMATE CHARACTERISTICS (SPECIFYING IRRIGATION WATER REQUIREMENTS)

Across the territory of R. Macedonia, three main climates are mixed: **continental**, typical for the northeast and higher regions of Macedonia, **Mediterranean** from Thessaloniki basin, mainly felt along Vardar river valley, and **mountainous** climate as a representative of the higher places and mountains. The orographic structure enables direct climate impacts from the north through the Kumanovo valley, and the impacts from the south arise from the Aegean see and enter through the Vardar valley. These climate impacts are felt deep into the country, thus the thermal difference between the north and south parts is mitigated. Maritime influences cause dry and hot summers, and continental impacts cause cold and wet winters.

The Sub-Mediterranean region covers Gevgelija-Valandovo and Dojran valleys where the Mediterranean climatic influences are most strongly felt. The region of noticeable transition of Continental and Mediterranean climate covers: Tikvesh, Veles and Skopje valleys, Ovche Pole, Shtip and Kochani valleys, the valley of the river Vardar, the Strumica-Radovish valley and the valley of the Crni Drim River in the Debar valley. To the north, along the valley of the river Vardar, this climate influence is rapidly weakening. The region of the continental climate is mostly felt in the Prespa and Ohrid-Struga valleys (where the influence of the lake basin is felt), Kichevo, Brodsko, Berovo-Delcevo, Slavik, Polog and Pelagonija valley.

For each of the proposed irrigation areas a representative weather station was dedicated for which the following climate parameters were analysed: temperature (T), relative humidity (%), solar radiation (SR), wind speed (WS) and precipitation (P).

Also, the rainfall amount and temporal variability is very important in activities related to hydrology, and especially in the estimation of crop water requirements. The characteristic of sub-Mediterranean zone is that the yearly rainfall sum is higher, in comparison with the one yearly rainfall in continental one.

Table 2-1 Climate characteristics for the analysed irrigation systems

	Irrigation Scheme	Representative Meteo. Station	Temperature	Relative Humidity	Solar Radiation	Wind Speed	Precipitation
			(^{0}C)	(%)	(h)	(m/s)	(mm)
1	Zajas	Kichevo	10.9	73	183.8	1.90	781.2
2	Kolibari	Kichevo	10.9	73	183.8	1.90	781.2
3	Slavishko pole	K.Palanka	10.3	69	188.9	2.78	635.9
4	DJK	Kumanovo	12.1	73	78.4	2.07	521.0
5	Konopnica	K. Palanka	10.3	69	188.9	2.78	635.9
6	Mavrovica	Shtip	12.9	67	197.6	2.48	475.3
7	Pishica	Kochani	13.2	70	197.6	1.17	515.6
8	Selemli	Gevgelija	14.6	69	196.5	1.89	700.8
9	Grchishte	Gevgelija	14.6	69	196.5	1.89	700.8
10	Chaushica	Strumica	12.9	73	193.2	1.06	583.9
11	Drazhevo	Strumica	12.9	73	193.2	1.06	583.9
12	Vasilevo-Dobrejci	Strumica	12.9	73	193.2	1.06	583.9
13	Konche	Radovish	12.3	72	193.2	1.94	423.6
14	K36	Kavadarci	13.2	71	197.6	0.80	454.2

15	Dabnichka reka	Kavadarci	13.2	71	197.6	0.80	454.2
16	Suvodolsko	Bitola	11.3	69	193.3	1.68	615.7
17	Gabalavci	Bitola	11.3	69	193.3	1.68	615.7
18	Desovo	Prilep	11.4	68	193.3	1.62	544.5
19	Tearce	Tetovo	10.7	74	149.8	0.68	810.3
20	Banjichko pole	Gostivar	10.3	75	149.8	1.12	793.5

Scenarios for the Impact of Climate Changes in Macedonia

To evaluate the impact of possible climate changes on the irrigation water requirements, data analysis was made for climate elements and their changes according to the study “Climate Change Scenarios for Macedonia”, prepared by the University of Nova Gorica, Centre for Atmospheric Research (Bergant K. 2006) and “Scenarios for climate changes in Macedonia”, prepared by Aleksandar Karanfilovski, 2012.

The prognosis of possible climate changes is performed by the method of proportional reduction (downscaling) of Global models at regional level. In general, minor changes at winter periods and more intensive changes at summer and autumn period are expected. Evident are changes of extreme temperatures, where the maximum temperature is with higher gradient than the minimal temperature, which reflects on increasing the average daily temperature.

Fifteen meteorological stations grouped into six climate regions according to the division of Filipovski are taken into consideration in the Study.

Projected changes of average, maximum and minimum daily air temperature (°C) and precipitation (%) for Macedonia based on direct GCM output interpolated to geographic location 21.5°E and 41.5°N, are presented in the following tables:

Table 2-2 Projected changes of average, min and max air temperatures (°C) (Bergant K. 2006)

T average (°C)	Dec/Jan/Feb		Mar/Apr/May		Jun/Jul/Aug		Sep/Oct/Nov		**Annual**	
Scenario	2025	2050	2025	2050	2025	2050	2025	2050	**2025**	**2050**
Low	0.7	1.4	0.7	1.3	1.2	2.2	0.8	1.5	**0.9**	**1.6**
Average	0.8	1.7	0.8	1.5	1.4	2.5	0.9	1.7	**1.0**	**1.9**
High	0.9	1.9	0.9	1.8	1.7	2.9	1.1	2.0	**1.1**	**2.1**
T мах (°C)	2025	2050	2025	2050	2025	2050	2025	2050	**2025**	**2050**
Low	0.50	1.2	0.6	1.3	1.3	2.6	1.0	1.7	**0.8**	**1.7**
Average	0.6	1.4	0.7	1.4	1.6	3.0	1.1	1.9	**1.0**	**2.0**
High	0.7	1.8	0.8	1.7	2.4	3.4	1.4	2.2	**1.3**	**2.2**
T мin (°C)	2025	2050	2025	2050	2025	2050	2025	2050	**2025**	**2050**
Low	0.8	1.7	0.7	1.2	0.9	1.9	0.8	1.5	**0.8**	**1.6**
Average	0.9	2.0	0.8	1.4	1.1	2.1	0.9	1.7	**0.9**	**1.8**
High	1.1	2.3	0.9	1.6	1.3	2.4	1.0	2.0	**1.0**	**2.1**

In case of precipitation projections, which are even more uncertain than air temperature projections, higher accuracy than 5% for the entire period of 21st century is not reasonable (Bergant K. 2006).

Table 2-3 Projected changes of average precipitation (%) (Bergant K. 2006)

P (%)	**Dec/Jan/Feb**		**Mar/Apr/May**		**Jun/Jul/Aug**		**Sep/Oct/Nov**		*Annual*	
Scenario / Year	2025	2050	2025	2050	2025	2050	2025	2050	**2025**	***2050***
Low	1	5	-3	-2	2	-16	2	-2	**-1**	***-2***
Average	0	1	-5	-6	-7	-17	-1	-4	**-3**	***-5***
High	**-2**	**-1**	**-7**	**-10**	**-24**	**-18**	**-3**	**-7**	-6	*-7*

Assessment of other climate elements (relevant for calculations of irrigation water requirement) such as solar radiation and wind speed, is performed at national level. For both elements the relative expected changes are small and do not exceed 5%. Minor increase in solar radiation is expected throughout the year, with extreme incidence during summer months. There is practically no change in the speed of the dominant winds over Macedonia.

In order to assess the impact of possible climate change on preselected irrigation systems, the values of the average scenario are entered in the historical climate data series, new sequences are generated, and consequently calculation of future climate elements are carried out.

The following table shows the estimated changes in the more important climate elements in the future for selected irrigation systems. Based on the expected changes in temperature, a quantitative assessment of the impact of future climate change on irrigation water requirements for all preselected irrigation systems is carried out.

The assessment was made only in relation to temperature changes, which has lower uncertainty in the forecasts compared to the forecasted rainfall changes.

Table 2-4 Expected Climate changes on main climate elements for the analysed irrigation systems

	Irrigation Scheme	T mean (^{0}C)	P mean (%)	P mean (mm)	Impact
1	Zajas	1.5	-2.3	-15.7	Low
2	Kolibari	1.5	-2.3	-15.4	Low
3	Slavishko pole	1.7	-3.4	-21.1	Medium
4	DJK	1.7	-3.4	-20.0	Medium
5	Konopnica	1.5	-2.3	-15.3	Low
6	Mavrovica	1.7	-3.4	-20.2	Medium
7	Pishica	1.7	-3.4	-20.4	Medium
8	Selemli	1.8	-3.4	-18.7	High
9	Grchishte	1.8	-3.4	-18.7	High
10	Chaushliska	1.7	-3.4	-20.2	Medium
11	Drazhevo	1.7	-3.4	-19.8	Medium
12	Vasilevo-Dobrejci	1.7	-3.4	-19.5	Medium
13	Konche	1.7	-3.4	-21.0	Medium
14	K36	1.7	-3.4	-19.2	Medium
15	Dabnichka reka	1.7	-3.4	-19.7	Medium
16	Suvodolsko	1.5	-2.3	-15.0	Low
17	Gabalavci	1.5	-2.3	-15.2	Low
18	Desovo	1.5	-2.3	-15.6	Low
19	Tearce	1.5	-2.3	-14.5	Low
20	Banjichko pole	1.5	-2.3	-14.8	Low

Due to a lot of uncertainties which cannot be avoided, we have to keep in mind that the projections of future climate are not exact predictions but only indices in which direction the climate change might develop.

WATER

WATER RESOURCES

The main objective of hydrological modelling is to estimate the hydrological potential of analysed watercourses. Since most of the rivers are not studied, several different empirical and other methods have been applied.

The results of hydrological models represent inputs into reservoir and water balance models with the main goal to meet all irrigation needs, based on required level of satisfaction of irrigation services.

As a final result, the size of the future arable area which can be quality irrigated was carried out respecting the ecological guaranteed flows and other water users.

RUNOFF ESTIMATION IN UNGAUGED CATCHMENTS

Runoff estimation based on aridity ratio:

This study explores how ungauged catchment heterogeneity and variability can be summarized in simplified models (due to scarcity of data), representing the dominant hydrological processes.

For a given region, the annual mean evapotranspiration and runoff rates are governed primarily by the amount of available energy (the demand) and precipitation (the supply). If the available energy and potential evaporation rates are fairly low, then for a given amount of precipitation, the runoff is likely to exceed evapotranspiration. Similarly, runoff would be expected to be a smaller fraction of precipitation if available radiative energy is very high resulting in high evapotranspiration.

The underlying purpose of this methodology is to develop simple models that can estimate the mean annual runoff according to the following formula,

$$Rt = Pt - Et = Pt - Pt * F(\phi) = Pt(1 - F(\phi t))$$

Where Rt, Pt, and Et are runoff, precipitation, and actual evapotranspiration during a year t, respectively. F(ϕt) is a functional relationship relating annual actual evapotranspiration to annual precipitation during year t:

$$F(\phi t) = \frac{Et}{Pt}$$

and ϕt is the aridity index [1], defined as

$$\phi = \frac{Eot}{Pt}$$

in which Eot is the potential evapotranspiration during year t [2].

The utilization of the above analysis is based on the availability of an appropriate functional relationship of the aridity index to estimate the ratio of annual evapotranspiration and annual precipitation. The aridity or dryness index after Budyko (1974) [1] represents the ratio of annual evapotranspiration to precipitation. Regions where aridity index is greater than unity are broadly classified as dry since the evaporative demand cannot be covered by precipitation. Similarly, regions with ϕ less than unity are broadly classified as wet.

There are three methods applied in this study [3], which operate at a mean annual time scale. Schreiber (1904) developed a simple formula for representing the evaporation ratio as a function of the aridity index in the form [2];

$$F(\phi) = \exp(-\phi)$$

Turc (1954) proposed a relationship which expressed evaporation ratio as a function of aridity index [1] in the form:

$$F(\phi) = \frac{1}{\sqrt{0.9 + (\frac{1}{\phi})^2}}$$

Budyko,[4], who accordingly proposed the geometric mean of the two relationships, further tested this relationship for 29 European rivers (Budyko, 1951) and then for 1200 regions for which precipitation and runoff data were available:

$$F(\phi) = [\phi \tanh(\frac{1}{\phi})[1 - \exp(-\phi)]^1/^2$$

Another statistical approach for estimating mean annual runoff was applied as well, Turc (1961) presented following relationship for watersheds with the area less than 300 km2 based on achieved results from doing a study on 254 watersheds in various climatic and weather conditions [5].

$$D = \frac{1}{\sqrt{0.9 + (\frac{P}{LT})^2}}$$

$$LT = 300 + 25T + 0.05T^3$$

$$R = P - D$$

Where:

P is annual precipitation, T is mean temperature in ˚C, R is annual runoff and D is annual flow shortage.

<u>Rational Method Runoff Coefficients:</u>

One of the parameters in the Rational Method equation (Q = CiA) is the runoff coefficient, C. The other parameters are A, the area of a watershed; i, the design rainfall intensity for a storm of specified recurrence interval and duration equal to the watershed time of concentration; and Q, the peak storm water runoff rate due to a storm of intensity ii, on a watershed of area, A, and with runoff coefficient, C.

The major factors affecting the rational method runoff coefficient value for a watershed are the soil type and the slope of the watershed. The physical interpretation of the runoff coefficient for a watershed is the fraction of rainfall on that watershed that becomes storm water runoff. Thus, the runoff coefficient must have a value between zero and one.

Slope: All other things being equal, a watershed with a greater slope will have more storm water runoff and thus a higher runoff coefficient than a watershed with a lower slope.

Soil Type: Soils that have a high clay content don't allow infiltration very much and thus have relatively high runoff coefficients, while soils with high sand content have higher infiltration rates and low runoff coefficients. The U.S. Soil Conservation Service (SCS) has four soil group identifications that provide information helpful in determining watershed runoff coefficients. The four soil groups are identified as A, B, C, and D. Classification of a given soil into one of these SCS groups can be on the basis of a description of the soil characteristics or on the basis of a measured minimum infiltration rate for the soil.

The descriptive characteristics of the four SCS soil groups are summarized in the following list:

Group A: Deep sand; deep loess; aggregated soils;

Group B: Shallow loess; sandy loam;

Group C: Clay loams; shallow sandy loam; soils low in organic content; soils usually high in clay;

Group D: Soils that swell significantly when wet; heavy plastic clays; certain saline soils.

Similarity based approach:

Continuous streamflow estimation is an important issue in surface hydrology, especially in ungauged watersheds. Since in ungauged basins, an observed streamflow time series is not available, the transposition of either gauged streamflow or model parameters from a similar and/or nearby gauged basin, called regionalization, is well recognized as a low-cost and popular solution to provide time series of streamflow at ungauged basins. Similarity based approach using geographical and hydrological similarities of the watershed was used for estimating discharge of ungauged basins based on measured data downstream. Mostly used method is using area proportion and precipitation proportion method to predict the flow from the small ungauged catchment upstream.

Other sources:

In addition to the empirical methods described earlier, data on hydrological values from other sources have been used, i.e.:

- Data on hydrological discharges from existing stations part of the state monitoring network, which are relevant (close) to the profiles of future intake structures;
- Data from already developed Studies and Technical Documentation of higher rank;
- Data from water utility companies that manage larger hydro-melioration systems;
- Data for groundwater availability in alluvial sediments near the major rivers, and
- Direct-immediate flow measurements, carried out by the project team.

Conclusions:

During the process of selecting the relevant discharges on which the size of the areas that will be covered by future irrigation systems depend, a more conservative approach is applied. The purpose of this approach is to reduce the uncertainties and risks that arise as a result of:

- Most of the existing hydro-melioration schemes are developed during the 70s with insufficient hydrological data;
- The newest hydrological data shows significant difference between the applied and actual discharges;
- Current utilization of existing irrigation schemes (significant differences between designed and actually irrigated area);
- Limited volume of the existing reservoirs and uncertainty about volume reduction as a result of sedimentation processes;
- Low sensitivity at larger inflows in to the reservoir, because of the limited reservoirs volume.

In the table below, values for annual average discharges for all selected systems are given, with some basic characteristics of their basins. A qualitative assessment of the water availability for irrigation needs has been also provided.

Table 2-5 Water source and basin characteristics for the selected systems

	IRR Scheme	Water source/type	Area (km2)	Slope (%)	Elev (masl)	P (mm)	Q (l/s)	Water availability
1	Zajas	Zajashka River, intake	64.0	8.6	715.0	783	1,150	Medium
2	Kolibari	Zajashka River, intake	86.64	3.69	652.58	781.2	1,510	Medium
3	Slavishko pole	Kriva Reka, intake	428.8	2.51	472.7	766.1	2,750	High/Medium
4	DJK	Kriva Reka, intake	945.1	1.53	307.1	716.2	4,720	High
5	Konopnica	River Krivo Moste, intake	8.68	12.14	644.5	798.7	84.0	Low
6	Mavrovica	River Orelska, dam	43.51	6.99	333	475.3	82.0	High
7	Pishica	River Pishichka, dam	14.4	7.9	366.8	635.4	36.2	Medium
8	Selemli	River Selemliska, dam	11.13	NA	NA	560	30.0	Low
9	Grchishte	River Vardar, intake	Underground water from Vardar aluvium deposits					High
10	Chaushliska	River Chaushica, dam	12.54	6.04	333.9	717.6	29.3	Medium/Low
11	Drazhevo	River vardar/Wells	Underground water from Strumica river aluvium deposits					Medium/High
12	Vasilevo-Dobrejci	River Vodochnica, Vodocha dam	Connected to dam Vodocha					Medium/Low
13	Konche	Vodeni dol, Konche, Koreshevec, Dam/Intake	18.95	NA	22.79	660.5	60.0	Medium/Low
14	K36	Crna River, Tikvesh dam	Connected to dam Tikvesh					High

15	Dabnichka reka	River Dabnichka, intake	19.7	10.5	273.3	634.7	112.0	Low
16	Suvodolsko	River Oreovska, dam	25.9	1.36	587	733.9	93.5	Medium/High
17	Gabalavci	Shemnica river, Strezevo dam	Connected to dam Strezevo					High
18	Desovo	River Suvodolichka, dam	5.12	4.15	692.3	740	21	Low
19	Tearce	River Bistrica, intake	Existing Small Hydro Power Plant				1,150	Medium
20	Banjichko pole	River Vardar, intake	100.8	3.41	548.1	837.1	2,500	High

For the systems which will be selected for Feasibility Studies stage, more detailed research and more precise hydrologic models will be carried on. The findings from the detailed hydrologic models may have influence on the future size of potential irrigation scheme.

Reservoir Modelling

Reservoir models are developed for existing and new irrigation schemes which have dams with reservoirs as a water source.

HEC-ResSim, a reservoir modelling package developed by the Hydrologic Engineering Center of the US Army Corps of Engineers, was used to model the reservoir's behaviour under the projected inflow series and calculated irrigation water demands. Schematics of the proposed simulation model layout are shown in Figures 1 and 2 respectively.

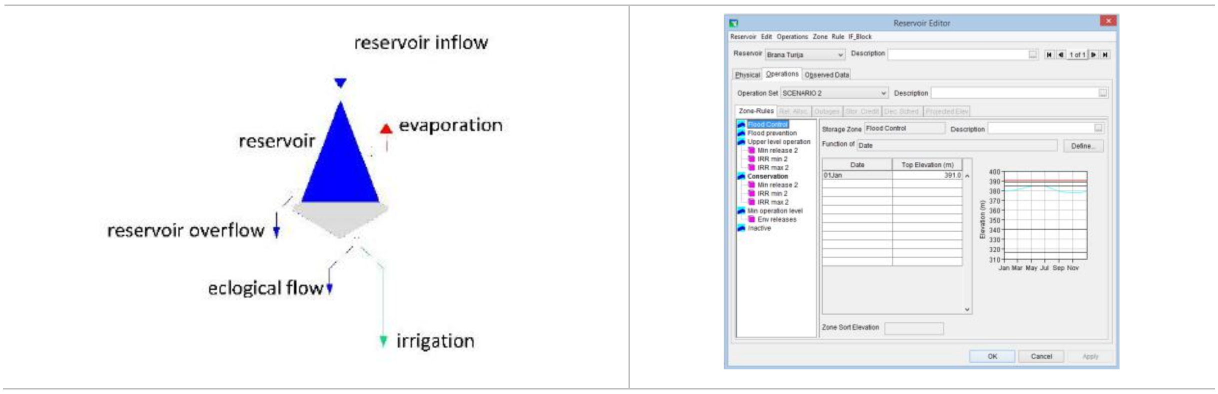

Figure 2-2 Schematics of the proposed reservoir simulation models

HEC-ResSim is a reservoir simulation software which simulates reservoir operations for flood management, low flow augmentation, water supply for planning studies, detailed reservoir regulation plan investigations, and real-time decision support. HEC-ResSim uses an original rule-based approach to mimic the actual decision-making process that reservoir operators must use to meet operating requirements for flood control, power generation, water supply, and environmental quality. HEC-ResSim can represent both large and small-scale reservoirs and reservoir systems through a network of elements (junctions, routing reaches, diversions and reservoirs) that the user builds. The software is based on earlier versions of HEC, but now makes use of Java code and graphical user interfaces. HEC-ResSim has a graphical user interface (GUI) and utilizes the HEC Data Storage System (HEC-DSS) for storage and retrieval of input and output time-series data. HEC-ResSim is a decision support tool that meets the needs of modelers performing reservoir project studies as well as meeting the needs of reservoir regulators during real-time events. Additionally, it can support real-time decision, using a real-time integrated database along with a user-friendly interface integrator like HEC-RTS or DELFT-FEWS.

The model allows the user to define alternatives and run simulations simultaneously to compare the results. HEC-ResSim offers several different ways of analysing results. These include graphical plots of time-series variables, tables listing time-series of variables, and summary reports listing statistical measures such as mean, maximum, minimum flow or water level. Many pre-defined plots, tables and reports are available. These pre-defined sets can be edited, or new sets can be created. This offers the possibility to produce outputs specifically focused on the problem to be analysed. In addition, the results can also be exported for post-processing in other software, such as for example MS Excel. The real value of the software is to view a graphical display of the results on screen, as HEC-ResSim offer an efficient and interactive way of analysing the time-series plots. Additionally, HEC-ResSim is compatible with ArcGIS shape files, which can be used as a background layer and facilitate the better representation of the physical system.

As input in creating the HEC-ResSim models of the reservoirs, we used the topographical features of the reservoir, hydrological data - inflows in the reservoir, water requirements for irrigation and ecological flow. The elevation-area-storage curves defines the basic properties of the reservoir, and subsequently is used for the mass balance accounting between the inflows and outflows. This curve is also used for determining the evaporation from the surface area of the water body.

For detailed documentation of the software, the reader is referred to the available HEC-ResSim website which has a manual consisting of 500 pages. It is recommended to check the website for model updates (Klipsch, 2007).

Initially in the water balance model, the following criteria were used for the fulfilment of the water demands to the users based on the following priority:

- Max. priority - ensure complete coverage of the required ecological flows;
- Minimize irrigation water supply deficit.

The created models are simplified water management models with one reservoir and several downstream users, sorted according the project priorities. In the analysis, the model uses the equation of continuity:

$\triangle V_{ak} = V_{inflow} - V_{outflow}$ $\quad V_{outflow} = B_{min}\ ;\ WS_i\ ;\ IRR_i$

$\triangle V_{ak} = (Q_{inflow} - Q_{outflow}) * T$, time-step T is one month.

Where the basic limitations on the controlled releases from the reservoir are as follows:

$$Yi_{min} \geq B_{min}$$

$$Yi_{max} \leq B_{min} + IRR_i$$

$$if\ Xi * T + V_{i-1} \leq V_{min}\ ,\ Yi_{max} = B_{min}\ ,$$

Y - reservoir releases   *X - reservoir inflow*   *B_{min} - ecological flow*   *IRR_i- irrigation requirements*

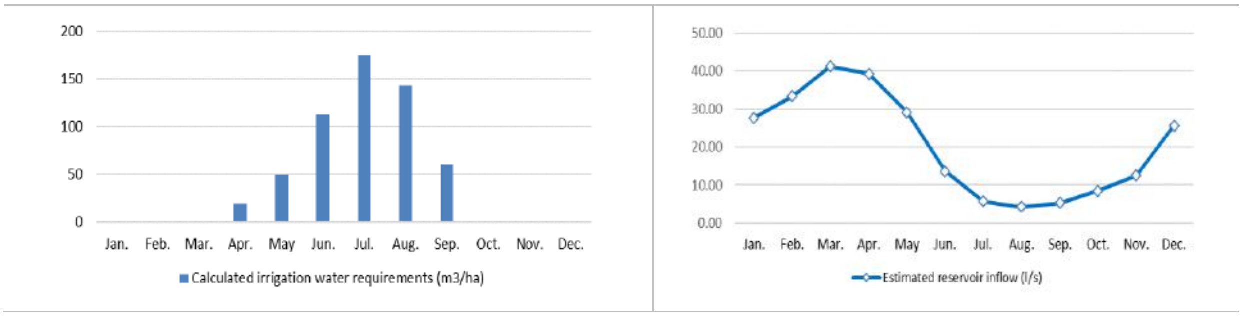

Figure 2-3 Example of the input parameters in the simulation model

In the water balance analysis, due to lack of available credible data mainly about the inflows in the reservoirs, we used deterministic approach with period of analysis of one year (average case scenario). The water balance models were implemented using monthly time steps, considering the natural hydrological inflows into the reservoir and the project criteria for meeting the priority demands downstream of the reservoir. Each reservoir operating goal is described by a flexibly-defined rule that, when evaluated, specifies a minimum or maximum limit on the release from the reservoir or outlet. The rules are placed in a prioritized list in one or more reservoir zones. As each rule is evaluated, its calculated minimum and/or maximum flow is applied to an evolving "allowable" range of release. Reservoir management system capabilities for downstream water management requirements must be evaluated from a reliability and risk perspective point of view, because inflows and other system variables are characterized by randomness, uncertainty, and great seasonal variability.

For the irrigation systems that are composed of two dams (Konche and Desovo) we have created additional simulation models that depict this, by creating a tandem operation rules to manage the storage distribution between upstream and downstream reservoirs on the same stream. In addition, HEC-ResSim supports parallel operation of reservoirs, where two or more reservoirs on different streams control for common downstream requirements, using common downstream control (for flow or stage limit) rules.

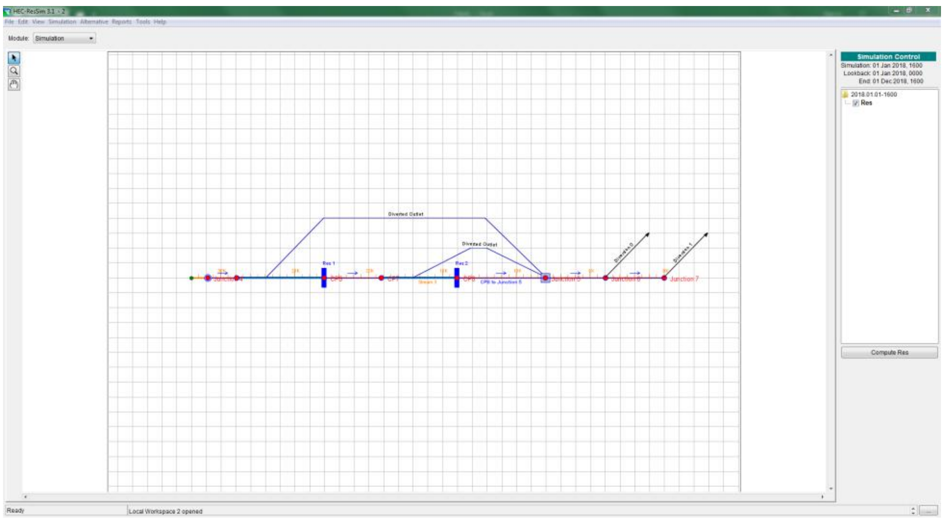

Figure 2-4 Example of two-reservoir water management model (HEC-ResSim)

For every analysed system we have developed three scenarios, with different size of irrigated area to precisely determine the possible area of irrigation. For every scenario we have created an output summary, consisting of tabular and graphical output. Some of the output graphs are presented with EXCEL charts for better presentation.

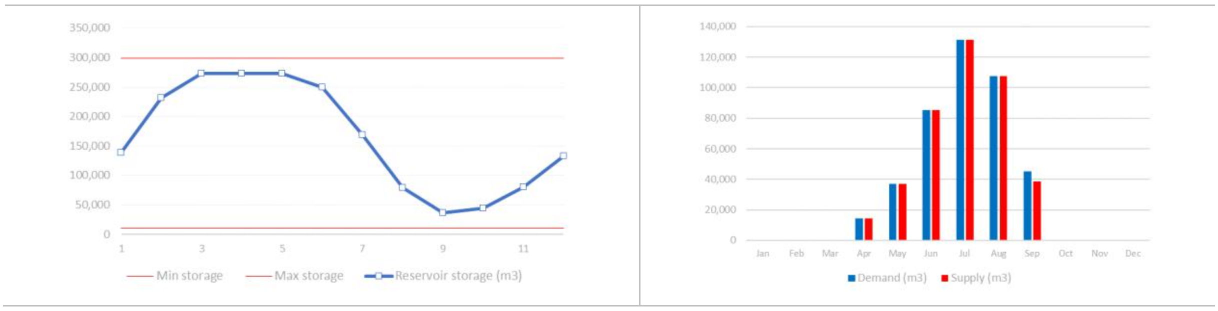

Figure 2-5 Example of the output parameters from the simulation model

Two measures of reliability were used: temporal and volumetric reliability. Both measures were calculated for irrigation - ecological flow daily, aggregated monthly and annually. Temporal reliability is defined as the proportion of total model time steps which have a demand for which that demand is not fully satisfied. Volumetric reliability is defined as the proportion of total volume of demand that is not fully supplied by the dam. Reliability indices provide a certain measure of the level of dependability at which environmental requirements, water supply, flood protection, seasonal irrigation demands, and other needs can be met. Reliability is a measure of the level of dependability at which various demands/needs can be supplied. Temporal reliability is based on simply counting the number of periods of the simulation, during which the specified demand target is either fully supplied or a specified percentage of the target is equalled or exceeded.

The application of simulation models is one of the most efficient ways of analysing water resources systems, which is based on physical relations accompanied by a series of operational rules under a specified policy. The input data considered for the model are monthly inflows, monthly irrigation and environmental diversion flow requirements and reservoir physical data. Temporal and volumetric reliability indices were used for system evaluation. A matrix of model runs for each analysed irrigation system is presented in the Annexes per location. Below is a summary table of the water availability analysis for the irrigation schemes that are consisted of reservoirs.

Simulation models summary table							
Irrigation system	Pishica	Mavrovica	Chaushica	Suvodol	Konche	Desovo	Selem
Region	East	East	South-East	Pelagonija	South-East	Pelagonija	South-E
Municipality	Probishtip	Sveti Nikole	Bosilovo	Novaci	Konche	Dolneni	Bogda
Water Economy	Zletovica	Bregalnica	Strumicko Pole	Bitolsko Pole	Radovishko pole	Prilepsko pole	Juzhen V
Dam construction	1962	1982	1993	1982	1960	1986	197
Dam condition	Not working	Working	Working	Working	Working	Working	Worki
Reservoir inflow (l/s)	36.2	82.0	29.3	93.5	8.0	20.5	
Catchment area (km2)	14.4	43.5	12.5	25.9	2.9	5.1	
Height of dam (m)	25.0	25.0	18.0	NA	8.0	11.0	
Crest elevation (m.a.s.l.)	367.6	378.0	410.0	692.0	474.0	746.0	
Max elevation (m.a.s.l.)	365.9	375.0	408.0	687.5	473.0	744.5	
Min elevation (m.a.s.l.)	345.6	362.5	393.0	675.0	465.0	735.0	
Active storage (m3)	700,000	2,523,000	139,400	4,456,908	99,000	77,400	80
Dead storage (m3)	40,000	277,000	600	665,140	11,000	1,300	10
Spillway capacity (m3/s)	NA	NA	38.0	NA	NA	15.0	
CWR (mm)	543.0	646.0	617.9	599.7	577.6	432.6	
Effective precipitation (mm)	242.0	237.0	255.7	267.7	251.9	224.7	
Irrigation efficiency (%)	85.0	70.0	85.0	85.0	85.0	85.0	
IWR (mm)	460.0	672.0	527.7	532.4	500.8	354.1	
Possible irrigation area (net)	180	460	60	270	45	110	
Possible irrigation area (gross)	200	500	70	305	50	130	

Figure 2-6 Example of the output parameters from the simulation models

It can be noted that the size of the irrigated area mainly depends on the available reservoir storage and hydrologic conditions. Some of the reservoirs can irrigate a very small irrigation area, mainly due to the limited reservoir storage while the reservoirs with larger volumes can provide water for larger irrigation areas. Reservoir Suvodol has a limited available reservoir storage. The reservoir is in good condition (in terms of dam stability), but the coal mine ''Suvodol” is located downstream of the dam, where in the past period in several occasions land slide has occurred. The land slide has damaged the evacuation organs of the dams, which are not in function. For this reason, reservoir Suvodol is limited to 680 masl (with allowable storage of 1.6 Mm3), which in turn has a negative impact on the size of the possible irrigated area.

For the later stages, more detailed reservoir analysis will be made, inspecting possible ways of increasing reservoir efficiency, developing seasonally variable reservoir guide curves and setting operational reservoir zones.

LAND RESOURCES

All of the proposed irrigation areas are situated in or along existing irrigation systems, where the soil suitability proved to be very good for irrigation.

All soil data parameters used were from MASIS - the Macedonian Soil Information System, which was developed with support from the Food and Agriculture Organization of the United Nations (FAO) and its Global Soil Partnership.

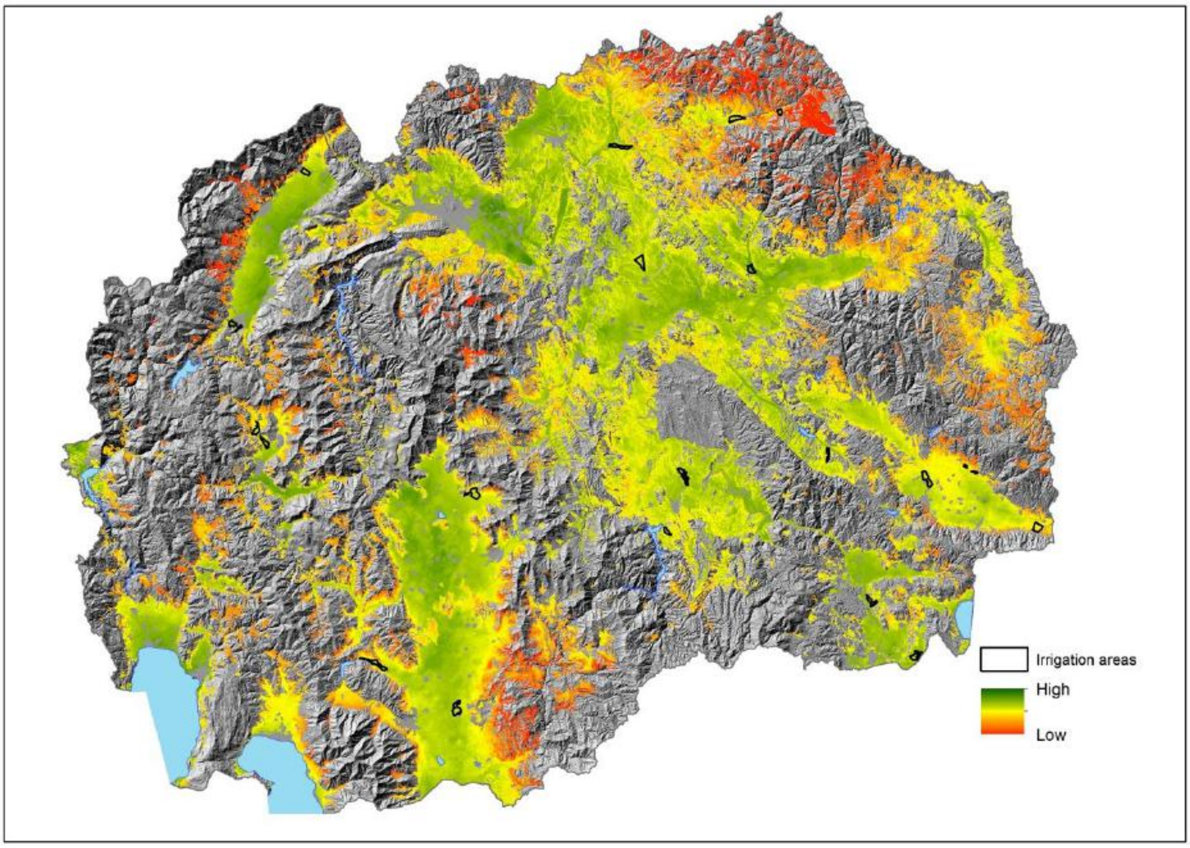

Figure 2-7 Soil suitability map and location of irrigation areas- source: MASIS

Soil suitability map for agriculture in general (shown in the figure above) was developed by means of the soil profile data and DSM / geo-statistics utilizing the soil profile/horizon data (mechanical, chemical and physical properties) and covariates, and the following layers were produced:

- pH-Soil reaction,
- Organic matter-OM content;
- Texture (clay, silt and sand content);
- Soil depth maps;
- $CaCO_3$ content.

The resulting DSM layers, non-soil data (precipitation, temperature and DEM-slope derivative), land evaluation criteria for Republic of Macedonia and expert knowledge-based functions was used in order to derive suitability map (source: MASIS). From the figure above, it can be noted that all of the proposed irrigation areas are situated in the zones, where the soil suitability is rated high.

Soil Type and soil texture classification is according to the FAO methodology, which is shown below in summary table.

Table 2-6 Soil Type and soil texture classification

	IRR Scheme	Soil Type, FAO classification	Soil texture
1	Zajas	Albic Luvisol with Fluvisol	Clay Loam with Sandy Loam
2	Kolibari	Dominant Fluvisol with very small area of gleysol	Dominant Sandy Loam
3	Slavishko pole	Fluvisol	Sandy Loam
4	DJK	Fluvisol	Sandy Loam
5	Konopnica	Dominant Fluvisol	Sandy Loam and Loam
6	Mavrovica	Dominant Complex of Vertisol and Humic Calcaric Regosol with smaller area of Complex of Fluvisol and Gleysol	Loamy clay with Sandy Loam
7	Pishica	Dominant Fluvisol with smaller areas of Complex of Vertisol, Regosol and Leptosol	Dominant Sandy Loam
8	Selemli	West: Chromic Luvisol on saprolite; East: Dominant Albic Luvisol with Fluvisol	Loam
9	Grchishte	Fluvisol with smaller area of Complex of Regosol and Leptosol	Sandy Loam and Loam
10	Chausica	Fluvisol and Rigosol	Sandy Loam
11	Drazhevo	Fluvisol	Loam with Sandy Loam
12	Vasilevo-Dobrejci	Fluvisol	Sandy Loam
13	Konche	Fluvisol	Sandy Loam
14	K36	Dominant Fluvisol with Complex of Humic Calcaric Regosol and Regosol	Dominant Sandy Loam with Loam
15	Dabnichka reka	Vertisol with Complex of Humic Calcaric Regosol and Regosol	Loam
16	Suvodolsko	Dominant Fluvisol with very small area of Gleysol	Dominant Sandy Loam
17	Gabalavci	Fluvisol	Sandy Loam and Loam
18	Desovo	Dominant Fluvisol with Complex of Cambisol and Regosol	Sandy Loam
19	Tearce	Fluvisol	Loam
20	Banjichko pole	Dominant Fluvisol with Complex of Chromic Luvisol on saprolite and Regosol	Sandy Loam

2.3 EXISTING STRUCTURES

The description and analysis of the present situation of the irrigation scheme in each project was performed in order to identify the assets and problems influencing the future development of the area. The information collected during the screening study was complemented by a second technical visit to the 20 selected locations to have direct contact with those who should have a significant participation in the project, farmers and other stakeholders in order to understand the problems of the area. The technical field visits performed by members of the team of consultants, are briefly described in the following table.

Table 2-7 Technical field visits performed

Date	Municipality visited	Branch name/ Area/ Dam:	People involved
19.09.2017	Strumica	Strumichko Pole; Chaushliska Dam; Vasilievo -Dobrejci, Novoselsko; Other small existing schemes (Bansko, Kolishimo, Mokrievo, etc)	Stojan Georgiev, Gjorgji Nacev
20.09.2017	Probishtip	Bregalnica Pole, Pishica, Blatec 1 and 2;	Jane Atanasov, Zoran Belicev, Gorgi Tusevski
20.09.2017	Delchevo	Public utility for communal services; Loshana, Petrasevsko;	Darko Gocevski
26.09.2017	Kriva Palanka	Konopnica, Mozdivnjak;	Martin Petkovski, Velinche Angelovski
27.09.2017	Gostivar	Kolibari, Crvevci, Mamudovci, Banjica;	Nasir Hasip, Pajtim Saiti
04.10.2017	Bitola	Strezhevo, Gabalavci, Sekirani, Kazhani, Suvodolsko/Novaci.	Ilija Grujoski
10.10.2017	Kumanovo	Kumanovsko-Lipkovsko Pole, Dovezence-Jachince-Klechovce (DJK), Studena vara, Shupliv kamen.	Filip Filipovski
12.10.2017	Prilep	Prilepsko pole, Podmol	Gordana Toshevska
24.10.2017	Sveti Nikole	Mavrovica	Goran Arsov
24.10.2017	Rankovce	Slavishko Pole	Goran Petkovski
24.10.2017	Konche	Konche	Vlado Iliev
24.10.2017	Novo Selo	Drazhevo	Petar Kostadinov
25.10.2017	Kavadarci	Tikvesh, Dabnichka Reka	Ljube Dimov, Risto Manev
25.10.2017	Dojran	Toplik	Ivan Vangelov
25.10.2017	Valandovo	Grchishte	Dushica Jovanova
25.10.2017	Veles	Podles	Risto Manev
26.10.2017	Tetovo	Dzhepchishte	Faradin
26.10.2017	Kichevo	Zajas 2	Vedat Ahmedi
26.10.2017	Debarca	Velmej	Goce Cvetkovski
27.10.2017	Desovo	Dolneni	Gordana Toshevska, Nikola Nastoski
01.11.2017	Tetovo	Tearce	Besim Imeri
01.11.2017	Bogdanci	Selemli	Ivan Vangelov, Aleksandar Kjirikj
01.11.2017	Gostivar	Banjicko Pole	Nasi Hasip, Pajtim Saiti
14.11.2017	Kavadarci	K-36	Risto Manev

Common findings in most of the visited sites:

- Most of the existing diversion structures either need rehabilitation or replacement by new ones;
- Only visual inspection carried out using the data available for dams and oral information was made during the field visits. In Macedonia, dams are regularly measured for checking the stability of the dam embankments. No stability problems were detected in the dams visited;

- Buildings of the existing pumps stations are generally in very bad condition and rehabilitation is proposed to be done with the new projects;
- Pumps do not exist in the buildings and new pumps are proposed for the projects;
- Buildings or boxes for bottom outlets of dams are not in good condition and rehabilitation or replacement with new ones depending on the project is proposed, to be done with the project;
- Valves for bottom outlets are either partially working or not working at all and should be replaced with the project;
- Pipes in the existing irrigation systems are in bad condition and most of their useful life is finished. They should be replaced with the project.

2.4 PROPOSED DESIGN

DESIGN CRITERIA

The design criteria described in this paragraph was used for the design of 20 small-scale projects at prefeasibility stage studies. In general, international and national design criteria are used as a principle. The main principles that guided the design at pre-feasibility study were:

- 1/25000 scale topographic maps and orthophoto maps were used for all projects so all projects have the same standard, although some of the projects had basic information with maps in larger scale;
- The irrigation area of each project was chosen considering that:
    - It is already within the existing irrigation scheme;
    - It is suitable for agriculture as shown on the soil classification maps of the region that the project is located on and
    - Farmers requirements for irrigation.
- Only modern irrigation systems (pressurized) with higher efficiency (for water economy) will be considered. All surface irrigation systems should be changed to pressure pipes;
- The adopted hydrant shaft is typical, reinforced concrete, prefabricated type, with a flow of q= 4,5 l/s for an area of 2 ha and a minimum operation pressure in the most unfavorable hydrant of 2.5 bar;
- It will be checked at first instance if there is natural pressure supplied by the topography to provide the required pressure to at least more than 80% of the irrigated area;
- If there is no natural pressure, a pump station will be proposed. Only electrical pumps are studied for supplying pressured irrigation water to the projects where required. Solar pump stations will be studied technically and financially at feasibility level;
- If irrigation water is taken from a river, a filter station at the intake structure is designed;
- Filter station is not designed if irrigation water is received from a reservoir of a dam;
- Ground water will not be used for irrigation except for the projects located close to rivers with high permanent flows, such us the Vardar River;
- The type of pipe will be HDPE for all pipelines in all projects;

- Pressure within the irrigation scheme pipeline network will vary between 6-10 bar for high pressurized irrigation schemes and will be lower for low and medium pressurized irrigation schemes;
- A pressure relief valve is designed if the pressure is greater than 10 bar in the irrigation pipeline network;
- Secondary pipelines will be located with 200 m intervals or smaller intervals depending on the irrigation scheme;
- The hydrants will be installed at an average distance of 100 m;
- The depth of the pipelines below ground level is assumed to vary between 1.00-2.00 m depending on the topography of the irrigation area;
- The main pipelines will be located parallel to the existing roads to be used for construction, operation and maintenance purposes, in order to decrease the expropriation costs;
- The main pipelines will be located on the same alignment with the existing canals and pipelines to decrease the expropriation costs;
- New service roads will be constructed if there is no existing road and/or canals and pipelines.

HYDRAULIC CALCULATION METHODOLOGY:

- The irrigation period will be 18 hours in the irrigation scheme;
- Velocity in the pipelines will be between 1.0 – 1.5 m/s.

For the design of the irrigation scheme pipeline network special software developed by Temelsu is used. It is based on the three main equations of fluid mechanics: continuity, momentum and energy equations. The high-pressure irrigation flow is considered to be steady, uniform and incompressible. Under these estimates continuity (1) and energy (2) equations, which are used mostly in the calculations of pressurized irrigation systems, are as follows:

Clement's Equation used for flow calculation:

Qe: Discharge at the downstream of section i
Qi: Cumulative imposed hydrant flow at the downstream of section i
N: Total number of hydrants at the downstream of section i
d: Nominal hydrant flow
r: Coefficient of utilization of the network
E: Net irrigation area coefficient
U: Coefficient about depending on probability of opened hydrant
q: Irrigation Module
$\sum_i S_i$: Cumulative gross irrigation area at the downstream of section i
X: Flexibility coefficient

$$A = \frac{E \times q}{\mathrm{r} \times \mathrm{d}} \times \sum_i S_i$$

$$N_i = \sum_i \frac{Q_i}{d}$$

$$N = \sum_i N_i:$$

$$X = \mathrm{A} \times \left(1 + U \times \sqrt{\left(\frac{1}{A} - \frac{1}{N}\right)}\right)$$

$$Q_e = X \times d$$

Hazen-Williams Formula:

$h = 10.67 \times q^{1.85} / (c^{1.85} \times d_h^{4.8655})$

where:

h: Head loss per unit pipe (m_{h2o}/m pipe)

c: Design coefficient determined for the type of pipe or tube - the higher the factor, the smoother the pipe or tube. 150 for epoxy and vinyl ester pipes

q: Flow rate (m^3/s)

d_h: Hydraulic diameter (m)

DRAWINGS

For the preparation of pre-feasibility level designs, computer aided design techniques are used. CAD (using Autocad Software) is used for the drawings required for the designs. The prefeasibility level drawings cover the following;

- Plans on 1/25000 topographic map,
- Plans on orthophoto maps.

2.5 PRELIMINARY ENVIRONMENTAL ASSESSMENT

The preliminary environmental assessment was performed using the INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (ICID) Environmental Check-list to Identify Environmental Effects of Irrigation, Drainage and Flood Control Projects (ICID,1993).

The main purpose of the ICID Environmental Check-list is to provide a tool which will enable specialists and non-specialists concerned with irrigation and drainage development to understand the environmental changes which such projects may bring so that adverse effects can be identified and, if possible, avoided or controlled, and positive effects enhanced.

The second purpose of the Check-list is to adapt and simplify existing approaches to environmental assessment to meet particular needs and to make the most effective use of available resources.

The principal means to achieve the efficient use of resources is to define more clearly those aspects of an assessment which must be performed by environmental specialists and those which can be accomplished by non-specialists. This allows the available environmental or other specialist expertise to be used most effectively.

The third aim is to bring together expertise from a wide range of sources concerning the environmental changes which relate to a specific group of projects: irrigation drainage and flood control projects and their dams. This allows a comprehensive framework to be established ensuring that no aspects are overlooked.

In this phase of the pre-feasibility studies, each of the proposed areas of evaluation listed in Annex 21 were considered and the expert opinion was marked in the Result Sheet for assessing the ICID Checklist. For each environmental effect a cross (X) was entered in one of the columns to indicate one of the following: positive impact very likely; positive impact possible; no impact likely; negative impact possible; and negative impact very likely.

Further details of the type of impact expected, the time-scale involved (e.g. short-term, immediate, permanent) as well as the cause of the impact would be described in detail in the prefeasibility studies.

When the assessment was complete, the number of crosses in each column were summed to give an indication of the number of responses in each category.

One of the principal ways in which the results are intended for use is in identifying those environmental effects which are likely to be the key issues in relation to the environmental impacts and sustainability of the Project.

Clearly the key issues are those which are associated with adverse impacts since the main objective of doing an environmental assessment is to identify ways in which adverse effects can be minimised.

Assessment of the importance of particular changes should start with a detailed study of each of the 'possible' or 'very likely' negative impacts to assess whether the changes have such serious implications that they might, by themselves, be considered sufficient reason to abandon or substantially modify the Project.

Another factor to record in the process of assessing and minimising adverse environmental changes, is the likely time-scale of the changes envisaged. How long will it take for the changes to take place and will they be temporary or permanent? This is particularly important with regard to proposing mitigating measures. Many adverse changes can be reduced by modifications to Project features by introducing special measures to counteract the effects of changes, or by ensuring that appropriate compensatory measures are provided.

The impacts during implementation phase were analysed and described separately after the evaluation of the more general environmental effects proposed to be evaluated using the ICID checklist.

2.6 AGRICULTURAL ECONOMICS

Agricultural production in almost all preselected schemes is limited which is conditioned by the dry conditions. Although most of the cultivated areas are covered by irrigation system, they are planted with crops which require less quantities of water because of lack of irrigation water.

CURRENT CROPPING PATTERN

The current utilization of the selected areas was obtained by analysing data on municipal level from the Agricultural census from 2007. According to this data in most of the analysed areas, most of the sown area consists of cereals. The representation of different crops for the areas according the census for agriculture in 2007 are given below.

Table 2-8 Current cropping pattern in the analysed irrigation systems according to agricultural census from 2007

IRR System	Crops (%)						
	Cereals	Industrial	Vegetables	Fodder	Orchards	Vineyards	Other
Zajas	58.2%	0.2%	18.5%	11.1%	11.8%	0.2%	0.1%
Kolibari	58.2%	0.2%	18.5%	11.1%	11.8%	0.2%	0.1%
Slavisko Pole	77.1%	0.1%	11.9%	4.4%	6.4%	0.1%	0.0%
DJK	85.1%	2.6%	4.1%	4.5%	0.7%	2.9%	0.0%
Konopnica	25.9%	0.5%	38.2%	10.6%	24.5%	0.2%	0.1%
Mavrovica	79.1%	2.8%	2.3%	9.2%	0.3%	6.3%	0.0%
Pishica	74.5%	8.3%	3.3%	5.3%	2.6%	6.0%	0.1%
Selemli	29.5%	0.2%	27.4%	4.8%	1.7%	36.4%	0.0%
Grchishte	30.0%	3.4%	17.0%	7.5%	8.3%	33.7%	0.0%
Chaushica	43.4%	9.4%	22.0%	21.7%	0.8%	2.6%	0.0%
Drazhevo	37.5%	8.4%	38.5%	11.1%	2.4%	1.9%	0.0%
Vasilevo-Dobrejci	38.0%	22.1%	20.2%	9.2%	1.7%	8.9%	0.0%
Konche	42.6%	37.1%	4.8%	7.9%	4.1%	3.4%	0.0%
K36, Sopot	2.6%	0.1%	2.1%	1.1%	2.9%	91.2%	0.0%
Dabnichka Reka	2.6%	0.1%	2.1%	1.1%	2.9%	91.2%	0.0%
Suvodol	79.1%	9.4%	2.9%	7.9%	0.3%	0.3%	0.1%
Gabalavci	62.8%	4.0%	10.0%	16.8%	3.4%	2.9%	0.0%
Desovo	60.5%	34.3%	1.5%	3.3%	0.2%	0.1%	0.0%
Tearce	71.6%	0.1%	9.3%	13.3%	4.4%	1.1%	0.1%
Banjicho Pole	56.9%	0.3%	14.8%	24.1%	3.8%	0.1%	0.0%

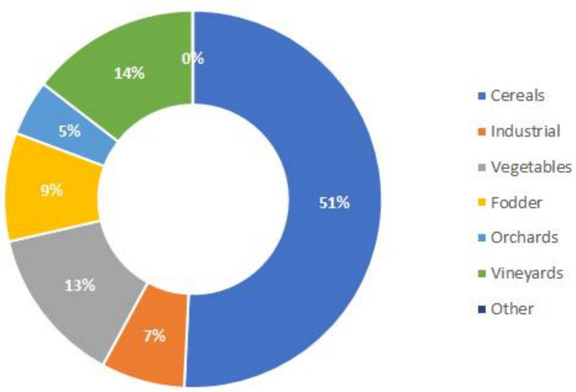

Figure 2-8 Average current cropping pattern in the analysed irrigation systems

Verification of the current cropping pattern was also obtained by analysing data from the "System identification of land parcels" which represents a system that identifies agricultural land currently being processed. The system uses precise flight footage which shows the real condition of the land and its utilization. Through LPIS[2], land parcels are graphically plotted, and exact area of land is automatically calculated.

For all analysed schemes (individual farmers and larger companies), the cereals are represented by ~ 51%. Other area is allocated to the vineyards 14%, vegetables ~13%, fodder crops ~9, industrial ~7%...

ANTICIPATED CROPPING PATTERN

The composition of the proposed crop types is given in the table below. This distribution is obtained from the cropping pattern for irrigated areas covered by the Public Water Enterprises. Verification of the current cropping pattern was also obtained by analysing data from LPIS.

Table 2-9 Proposed cropping pattern for the analysed irrigation systems

Proposed cropping pattern for the analysed irrigation systems

IRR System	IRR Crops (%)						
	Cereals	Industrial	Vegetables	Fodder	Orchards	Vineyards	Other
Zajas	46%	10%	29%	6%	6%	0%	2%
Kolibari	46%	10%	29%	6%	6%	0%	2%
Slavisko Pole	49%	2%	40%	1%	7%	0%	2%
D-J-K	70%	4%	18%	3%	2%	1%	2%
Konopnica	15%	1%	70%	2%	11%	0%	1%
Mavrovica	43%	8%	7%	33%	1%	6%	1%
Pishica	51%	5%	30%	3%	5%	4%	2%
Selemli	5%	1%	54%	3%	3%	33%	1%
Grchishte	11%	1%	27%	5%	9%	46%	0%
Chaushica	40%	18%	35%	2%	2%	2%	1%
Drazhevo	31%	8%	53%	2%	4%	1%	1%
Vasilevo-Dobrejci	28%	22%	30%	7%	3%	8%	0%
Konche	12%	8%	56%	3%	18%	2%	2%
K36, Sopot	3%	0%	3%	0%	4%	89%	0%
Dabnichka Reka	3%	0%	3%	0%	4%	89%	0%
Suvodol	41%	21%	14%	17%	2%	1%	5%
Gabalavci	45%	13%	21%	9%	6%	2%	4%
Desovo	30%	44%	20%	2%	1%	0%	2%
Tearce	70%	2%	11%	6%	5%	1%	6%
Banjicho Pole	57%	3%	23%	5%	4%	0%	8%

[2] Land Parcel Identification System

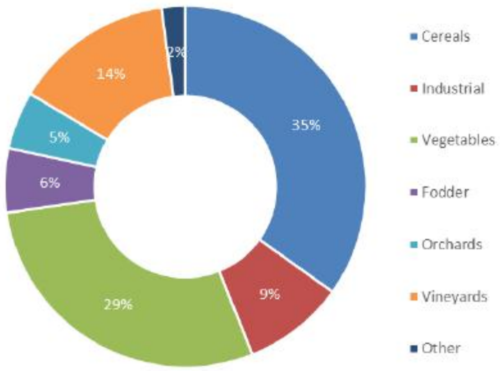

Figure 2-9 Average proposed cropping pattern in the analysed irrigation systems

For the later stages of the Project, for better determination of the proposed cropping pattern, we recommend more detailed analysis to be made, conducting additional field surveys, preparing questionnaires and on-site field data base, consultations with local farmers and water management organizations, where the final cropping pattern should be approved by the farmers i.e. the users of the system.

During the selection of cropping pattern for the schemes which will be selected for further development, beside the principle for maximization of the effects from irrigation, other factors will be also considered:

- Introduction of crops typical for irrigation conditions with high yields and profitability, in order to get profitable irrigation investment;
- Introduction of second crops cultivation that will result in increased production per unit area, especially on low profitable crops (wheat and barley) after which, secondary crops can be grown (hybrid corn for seed with a short vegetation, tomatoes and cabbage);
- Introduction of crops that will provide cash overcome so farmers could provide income over a longer period, thereby their economic power will increase. Such crops are gardening with more harvests over the vegetation that have high market potential;
- Forage crops that have a positive impact to improve the quality of soil and to provide fodder locally.

IRRIGATION WATER REQUIREMENT

AIMS AND APPLIED METHODOLOGY

The purpose of the analysis is to determine the irrigation water requirements in accordance with the adopted cropping pattern. The composition of applied crops is determined by previously described principles according to the existing Agriculture censuses, surveys and current agricultural practices in the region.

To increase the reliability of irrigation, all generated data series for irrigation water requirements are for the period from 1961 to 2005 (2015), where requirements are represented with fixed discrete intervals depending of requirements as follows: daily, decimal, monthly and yearly. Sophisticated computer programs and specific tools for database processing (Access, Excel), statistical processing

(Excel, Statistical), determining the demand for water (CropWat, CropSys, ClimGen, Aqua Crop), etc. are applied.

During the preparation of this section of the Study, the following documentation was used:

- Study SAPROF[3];
- Scenarios for climate changes in Macedonia;
- Agriculture Census, 2007;
- Statistical Bulletin for Farming, Orchards and Livestock for 2009 up to 2013;
- FAO Irrigation and Drainage Papers 24, 25 and 56.

Crop water requirements are determined based on the FAO Irrigation and Drainage paper 24, 25 and 56. The FAO software CROPWAT 8.0 is used for the analysis. Initially, the reference evaporation is determined in accordance with the modified Penman-Monteith method. Consequently, the reference evaporation method is used for determination of irrigation water requirements with application of crops coefficients given in the FAO reference and adapted for our circumstances.

Irrigation water requirements are further calculated. These calculations include effective precipitations. After the calculation of irrigation water requirements, specific continuous discharge i.e. hydro modules are calculated, which by recommendation from the FAO paper are presented as average monthly continuous flows, namely as continual irrigation of 24 hours, for each irrigation day. This valuation can be transferred as valuation for short irrigation (20 hours, 18 hours etc.).

REFERENCE EVAPORATION (ETO)

Reference evaporation according to the FAO recommendation represents the evaporation of well irrigated and optimally maintained grass with height of 10 cm. These calculations are made based on the FAO 24 and 56 methodology using software CROPWAT 8.0. This methodology is considered as one of the most accurate. The reference evapotranspiration is obtained by the measured data from the representative meteorological station for each area.

CROP WATER REQUIREMENTS

The total crop water requirement is defined as the quantity of water needed to meet the water consumption by crops that grow in compact plantation, on larger area not infected with diseases, and without any restrictive factors (FAO irrigation and drainage paper No. 24, Crop Water Requirement). It represents the water requirements for each crop and depends on the climate conditions and the crop itself; transpiration and evaporation of the soil are also taken into consideration.

The effect of each crop on the overall irrigation water requirements is determined by the so-called crop coefficient (Kc), which shows the relationship between evaporation reference (ETo) and evaporation culture (ETc). Coefficient values of the crops differ for each crop, but also differ for the same crop depending on the stage of growth, the period of vegetation and weather conditions of that period. Evaporation of the crop is defined in mm/day as an average value. The calculation is performed by the formula:

[3] Structured Assessment of Protective Factors for violence risk

$$ETc = ETo \cdot kc$$

ETc (ET crop) – evaporation of the crop or crop water requirements of any period in mm

ETo – reference evaporation for the same period in mm

Kc – crop coefficient for the same period

Depending on the crop, stage of development and growth, the crop evaporation may be higher, equal or less than the reference evaporation. In principle, the values for the initial and final development phases are lower than the reference evaporation. In complete development phase, depending on the crop and its water requirements values are usually lower, and only for crops with very high water requirements they are equal or greater than the reference evaporation.

The total water consumption is determined by the FAO methodology with application of crop coefficients by phases of development, provided by FAO and corrected and adapted for our conditions. Based on the data on reference evaporation and crop coefficient values at each phase of development, total crop water requirements are determined.

IRRIGATION WATER REQUIREMENTS

Irrigation Water Requirements according to the FAO methodology, is the required water quantity for irrigation (irrigation norm) determined as subtraction between total crop water requirement and effective precipitation:

IWR = ETc - Peff

IWR - required water quantity for irrigation (irrigation norm) in mm

ETc - crop evaporation (total crop water requirement) in mm

Peff - effective precipitation in mm

Summary data series of precipitation per year over the analysed period are decreased by the level of efficiency of the soil moisture transformation and crops accessibility. Among all other methods, FAO is recommended as a method of fixed efficiency, especially for those areas which have not been explored enough for the influence of soil and crops of effective precipitation usage.

Effective precipitation depends on climate, topography, soil structure, initial soil moisture, irrigation method, crop rooting depth, crop cover, etc. For the calculation of the effective precipitation we have used the FAO recommendation for dependable rain formula application i.e.

Peff = 0.6*P - 10/3 for P month <= 70/3 mm

Peff = 0.8*P - 24/3 for P month > 70/3 mm

It can be concluded that the effective precipitation for semi dry year (75%) in the period of vegetation is almost negligible, and crop cultivation without intensive irrigation is debatable and it is not certainly that it would be profitable.

SPECIFIC CONTINUOUS DISCHARGE

Based on the previous data, total water irrigation requirements are determined by the considered land utilization. This calculation is performed by multiplying irrigation water requirements per unit surface with the represented area. The Specific continuous discharge - Hydro module is calculated using the following formula:

$$q = \frac{\alpha * IWR}{0.36 * n * t}$$

α - The relative contribution of crop in the seedtime structure

IWR - required quantity of water for irrigation (IWR) in mm

n - Number of hours for watering for 24 hours (the calculations are for 24 hours)

t - Number of days for watering (recommended daily watering during vegetation)

The efficiency of water usage for irrigation depends on the applied irrigation technique. The efficiency of individual irrigation techniques in agricultural area (distribution of water in the field) are taken as 85-90% for micro irrigation, 70-80% for sprinkler techniques, and 50-70% for gravitation irrigation techniques.

Table 2-10 Summary table - crop water requirements for the analysed irrigation schemes based on proposed cropping pattern

	IRR Scheme	Kc (IRR)	Eto	CWR	IWR	FWR (75%)
		-	(mm)	(mm)	(mm)	(lit/sec/ha)
1	Zajas	0.59	836.6	511.7	419.9	0.68
2	Kolibari	0.43	836.6	511.7	419.9	0.68
3	Slavishko pole	0.45	909.9	508.5	396.7	0.66
4	DJK	0.46	759.8	446.6	377.6	0.72
5	Konopnica	0.58	909.9	489.8	373.3	0.56
6	Mavrovica	0.50	1030.7	710.8	669.3	0.82
7	Pishica	0.45	876.5	510.8	452.3	0.71
8	Selemli	0.56	1000.1	667.8	577.9	0.56
9	Grchishte	0.56	1000.1	651.8	562.9	0.59
10	Chausica	0.63	864.8	617.9	527.7	0.68
11	Drazhevo	0.65	864.8	633.5	542.6	0.64
12	Vasilevo-Dobrejci	0.52	864.8	599.8	512.2	0.66
13	Konche	0.49	902.0	573.2	568.3	0.74
14	K36	0.52	851.2	518.8	473.0	0.47
15	Dabnichka reka	0.52	851.2	518.8	473.0	0.47
16	Suvodolsko	0.53	908.5	599.7	532.4	0.80
17	Gabalavci	0.48	908.5	584.5	521.3	0.80
18	Desovo	0.37	896.9	432.6	354.1	0.52

19	Tearce	0.59	721.0	471.1	385.6	0.59
20	Banjichko pole	0.48	739.3	484.5	382.8	0.54

AGRICULTURAL ECONOMICS

One of the most significant aim of the project is supplying water for irrigation of all preselected irrigation schemes around the country. The irrigation of the farmland shall certainly result in increased yield (agricultural productivity) and benefits.

Analysis of the more important crops in terms of incomes and profits is carried out with data from similar projects at the state level, prepared by the Faculty of Agriculture and Forestry.

The calculations refer to the most dominant crops for two scenarios: (1) with irrigation and (2) without irrigation, for crops where production without irrigation is possible.

- Benefit Analysis includes: income from the agricultural product, income from the secondary products and income from subsidies;
- Cost analysis, contains the following parts: Variable costs (seeds, fertilizer NPK, fertilizer N, pesticides, fuel, lubricants, irrigation, harvesting, labour and other variable costs) and Fixed costs (insurance, depreciations, interest working capital and other fixed costs).

Below is a table with summarized indicators, for some of the crops with and without irrigation.

Table 2-11 Summarized financial indicators for crops without and with project (Denars per hectare)

	WITHOUT (not irrigated)				
	Winter wheat	Barley	Tobacco oriental	Grape	Orchards
Total incomes	41,000	36,100	276,000	160,000	0
Total variable cost	29,970	29,270	217,758	111,300	0
Total fixed cost	4,039	3,867	17,742	11,896	0
Total costs (F+V)	34,009	33,137	235,499	123,196	0
Profit	6,991	2,963	40,501	36,805	0
	WITH PROJECT (irrigated)				
	Winter wheat	Barley	Tobacco oriental	Grape	Orchards
Total incomes	61,000	36,100	460,000	220,000	373,000
Total variable cost	40,828	29,270	310,876	146,078	283,850
Total fixed cost	5,019	3,867	25,081	15,613	33,375
Total costs (F+V)	45,847	33,137	335,956	161,691	317,225
Profit	15,153	2,963	124,044	58,309	55,775

In order to estimate the average (weighted) income from agricultural activities at the irrigation scheme level, these values are applied to the current and to the anticipated cropping pattern. Assessment of the positive effects from irrigation is carried out using a scenario (model) that simulates the changes in the production-yield and cropping pattern.

Table 2-12 Summary results of expected benefits without and with project (Denars per hectare)

	IRR Scheme	Current cropping pattern	Anticipated cropping pattern	Ratio
1	Zajas	54,072	176,406	3.3
2	Kolibari	51,133	176,406	3.4
3	Slavishko pole	44,677	161,076	3.6
4	DJK	40,891	161,076	3.9
5	Konopnica	49,455	220,885	4.5
6	Mavrovica	50,447	109,191	2.2
7	Pishica	41,967	153,131	3.6
8	Selemli	73,353	291,372	4.0
9	Grchishte	59,633	249,709	4.2
10	Chaushliska	62,237	247,109	4.0
11	Drazhevo	64,356	280,172	4.4
12	Vasilevo-Dobrejci	43,252	255,648	5.9
13	Konche	96,416	305,047	3.2
14	K36	146,995	225,851	1.5
15	Dabnichka reka	146,995	225,851	1.5
16	Suvodolsko	52,293	176,792	3.4
17	Gabalavci	52,293	182,101	3.5
18	Desovo	104,378	196,150	1.9
19	Tearce	51,917	159,620	3.1
20	Banjichko pole	51,917	159,620	3.1

It can be noted that the revenues from the current agricultural activities are relatively low and uniformed for all systems. Higher incomes occur in systems where crops which also have certain yields without irrigation (vineyards, tobacco), are cultivated.

Almost all systems have a significant increase in yields and gross benefits. The average increase for all analysed irrigation schemes is ~3,5 times.

In the Economic analysis of implementing irrigation projects, comparison between the whole area of the future schemes cultivated with agricultural crops which can be grown without irrigation and the same area with a new cropping mixture that have greater economic significance, are considered as a basic principle.

2.7 PROJECT COST ESTIMATES

The following key issues considered for preparing the bill of quantities (BoQ) are given below:

- Items in the BoQ will cover all kinds of works to be done for complete functioning of the item;
- Service Road items cover all kinds of earth works for complete functioning of the service road;
- Items for intake structures cover all kinds of earth and concrete works including mechanical works for complete functioning of the structure;
- Items for pump stations will cover building, pump procurement, installation, testing and all accessories for complete operation of the pump stations;
- Repair items will cover all kinds of earth, concrete and mechanical works for re-functioning of the structure.

The investment analysis consists of preparation of bills of quantities and cost estimation of all types of civil and installation works and equipment purchase. Unit work quantities and costs in the analysis are assumed based on experience from similar projects; some items are calculated in detail and some are taken as a percentage of the detailed costs. Prices are related with current market conditions; contingencies are included as well. For all alternatives calculations are made using equal conditions and unit prices.

The investment (capital) costs are distributed in several major components, depending on the considered irrigation scheme:

- Costs related to construction of new wells;
- Costs related to construction of new intake structures or rehabilitation of existing ones;
- Costs related to construction/rehabilitation of dams/reservoirs;
- Costs related to reconstruction of pumping stations;
- Costs related to reconstruction of filter stations;
- Construction of main water supply pipelines;
- Construction of secondary irrigation distribution network for the cultivated fields;
- Other expenses for smaller structures.

Detailed analysis of the investments for all alternatives is presented in Annexes. Overview of investment costs by components and the total investment are given in the Table below.

Table 2-13 Overview of investment costs by components and the total investment

	IRR Scheme	Intake structure	Dam and structures	Pump station	Main pipeline	IRR Network	Filtration units	TOTAL	Unit system costs (euro/ha)
1	Zajas	/	/	68,939	464,167	693,000	77,516	**1,303,622**	**7,760**
2	Kolibari	86,793	/	68,939	355,466	660,000	75,640	**1,246,838**	**7,793**
3	Slavishko pole	70,798	/	/	500,718	969,375	97,358	**1,638,250**	**6,971**
4	DJK	70,798	/	84,692	600,423	969,375	103,601	**1,828,889**	**7,783**
5	Konopnica	56,638	/	/	93,670	412,500	48,418	**611,226**	**8,732**
6	Mavrovica	/	/	/	2,249,685	1,155,000	/	**3,404,685**	**12,160**
7	Pishica	/	/	/	111,647	682,894	/	**794,540**	**4,674**
8	Selemli	/	7,700	142,984	296,151	888,608	/	**1,335,442**	**6,183**
9	Grchishte	/	/	644,937	284,133	345,146	/	**1,274,215**	**8,495**
10	Chaushliska	/	22,000		152,967	288,750	/	**463,717**	**6,625**
11	Drazhevo*	52,939	/	479,373	215,205	752,535	/	**1,500,053**	**7,500**
12	Vasilevo-Dobrejci	/	/	/	530,128	482,098	301,900	**1,314,126**	**4,380**
13	Konche	38,939	163,547	/	265,188	412,500	35,843	**916,017**	**9,160**
14	K36	7,080	/	76,692	427,747	1,072,500	/	**1,584,019**	**6,092**
15	Dabnichka reka	15,932	/	/	180,150	453,750	47,569	**697,402**	**6,340**
16	Suvodolsko	/	/	/	201,007	1,258,125	/	**1,459,132**	**4,784**
17	Gabalavci	/	/	/	956,715	1,122,000	/	**2,078,715**	**7,642**
18	Desovo	/	72,180	/	188,566	528,000	/	**788,746**	**6,162**
19	Tearce	17,699	/	/	295,223	660,000	69,908	**1,042,831**	**6,518**
20	Banjichko pole	14,160	/	/	818,385	717,750	69,521	**1,619,815**	**9,309**
	TOTAL/Average	431,776	265,426	1,566,556	9,187,340	14,523,905	927,276	**26,902,279**	**7,253**

*Data for the alternative with pumps is presented, because of the lower investment value and better economic parameters.

The total investments required for implementation of all 20 preselected irrigation schemes is estimated at €26.9 million. The specific investment value per unit hectare, ranges from 4.380 to 12.160 (7.250 Euro/ha on average), as it is expected for this type of smaller investment projects.

According to the investment analysis by mentioned components, the greatest part of the total investment refers to construction of secondary irrigation network for the cultivated fields (54%), followed by costs for installation of main water supply pipelines (34%).

2.8 ECONOMIC AND FINANCIAL ANALYSIS

ECONOMIC COST-BENEFIT ANALYSIS

AIM OF THE ANALYSIS AND METHODOLOGY

The aim of the economic (or socio-economic) cost-benefit analysis is to assess the overall impact of a project on improving the economic welfare of the citizens of the concerned society. The economic analysis of the project is similar to the financial analysis in the aspect that both analyses assess the profit from the investment. The financial profit, however, is not the same as the economic profit. The financial analysis of a project assesses the fiscal profit accruing to the project implementing entity, whereas the economic analysis measures the effect of the project over the national economy. However, in order one project to sustain economically it must be financially sustainable as well, given that if the project is not financially sustainable, the economic benefits would not be realized.

The process of conducting economic analysis of the costs and benefits involves recalculation of the cash inflows and outflows in the financial analysis using conversation factors to reflect real economic costs, and to include benefits and social costs not considered by the financial analysis. This involves the conversion from market prices to accounting (or shadow) prices to take account of market distortions and to include externalities, which lead to costs and benefits not included in the financial analysis since they do not generate money expenditure or income.

There are three basic steps in analysing the economic viability of a project, these are:

- Externalities Corrections: identifying, quantifying and valuing in monetary terms (and to the extent possible) the economic (external) costs and benefits;
- Fiscal Corrections: conversion from market to accounting (shadow) prices;
- Comparing the benefits with the costs.

The results and the conclusions from the economic analysis of all the preselected projects according to the selected technical alternative are presented further on in the text.

External project benefits and costs

Increased agricultural production:

One of the most significant aim of the project is supplying of water for irrigation of all preselected irrigation schemes around the country. The irrigation of the farmland shall certainly result in increased yield (agricultural productivity).

Assessment of the positive effects from irrigation is carried out using a scenario (model) that simulates the changes in the production. Description of these analysis as well as the incremental changes in the crops for the adopted structure of agricultural crops on the Project area are given in Section 2.6 (Agricultural economics). The value of the increased production, however, is assessed on the basis of background data for variations of market prices of applied agricultural crops. For each of the represented agricultural crops separately data for the market prices from Faculty of Agriculture and Forestry are used.

On basis of the projections for incremental changes in the production of major represented agricultural crops and the projected trend of the changes in crops' market prices, an economic (monetary) value of the increased agricultural production for the analysed 25-year period is obtained. The average net value (incremental revenues minus incremental costs) for all applied crops for all preselected schemes is between €40,000 to around €240.000 annually. Details from the analysis are presented in the Annexes.

Increased costs of the Agriculture production:

One of the external costs (adverse effect) which occurs as a result of the project, is the increased costs which shall be borne by the farmers for the increased Agriculture production. The analysis of these costs is made on the basis of background data for the average: (1) direct costs (fertilizers, pesticides, tractor hours, maintenance of fixed assets and other smaller tangible costs); (2) labour (work hours); and (3) indirect costs (sale, marketing, management, insurance, loans, depreciation) which shall be borne by farmers taking into consideration all agricultural crops and their representative quantities. Again, only the incremental values of the change (increase or decrease) of the production is taken into consideration.

Other benefits:

As an additional income from the implementation of projects, a discounted residual value of anticipated net economic benefit after the analysed period of 25 years was considered. This value is calculated by the formula:

$P = B * \left(\frac{1+I}{DR-I}\right)$ Where, B-Average Net Benefits, DR-discount rate, I-Inflation

Fiscal correction and conversion in the accounting prices

The market prices of goods and services considered in the financial analysis include a number of items that need to be deducted to achieve their real economic prices. These include taxes, subsidies and transfer payments, such as: (1) Value Added Tax (VAT); (2) subsidies; and (3) other indirect taxes. These items are deducted.

The next step in the economic analysis is to convert the items from market prices to accounting prices using conversion factors. This is made because the current prices of inputs and outputs do not reflect their real social value because of distortions in the market. These distortions may include such items as: trade barriers, poor labour productivity, etc.

In case of the analysed project, the construction of the irrigation system and the O&M costs are connected with local labour, local/domestic goods and equipment, and small part of imported goods and equipment. The percentage of each of these positions in the total cost has been assessed; also, a description of the applied conversion factors is given.

Local labour (salaries): for all categories of local workforce the factor of conversion is calculated as follows:

CF = (100 – UR)/100 = 0.75

Where:

UR – actual unemployment rate

CF – conversion factor

Foreign labour: no cost adjustments are made as financial prices are expressed in border prices. The percentage of foreign labour costs during construction is estimated to be 0% of the total investment.

Local goods: The biggest part of the goods (materials and equipment) for construction and for operation and maintenance will originate from domestic manufacturers. No reconciliation (conversion factor 1) had been performed because the financial costs are VAT excluded.

Imported products: the major items of imported products and equipment to be used for construction and maintenance the irrigation system includes: steel products, fuel and certain part of the equipment/machinery. The average percentages from these positions in the total costs are estimated on the basis of the review of the investment costs. Applied conversion factors for all imported products (without diesel oil) regarding the fact that these products are to be imported from EU -member state, amounts to 1.

Diesel oil: The applied conversion factor equals 0.76, calculated as a ratio of maximum allowable production / border diesel fuel prices in Macedonia for the period 2008/2009 and the current market price.

Land (as a specific non-tradable good): it is assumed that the local real estate market is sufficiently representative of the alternative use-values of land, hence the current market price is used in the analysis (conversion factor 1).

Table 2-14 Conversion factors

Item	CF
Land	1.000
O&M	0.925
Civil works, Preparatory works, geodetic surveys	0.750
Irr. Network, Piping, Structures and Objects	0.850
Equipment and installation works	0.850

Power supply and automation	0.850
Contingency	1.000
Energy Consumption for Pumping	0.960

Results from the economic analysis

The assessment of the project performance in economic terms, i.e. from the viewpoint of the society, is based on comparison of the cost and benefits with the applied corrections for price distortions and externalities (as described above) and calculating the net benefits. Summary information from the economic cost-benefit analysis is presented in the Table below; details are given in Annexes.

Table 2-15 Summary results of the economic cost-benefit analysis

	IRR Scheme	B/C	ENPV (at 4% discount rate)	EIRR
1	Zajas	1.3	378,841	5.7%
2	Kolibari	1.4	515,815	6.3%
3	Slavishko pole	1.3	624,563	6.1%
4	DJK	1.2	411,936	5.3%
5	Konopnica	1.3	228,959	6.1%
6	Mavrovica	1.0	-98,602	3.8%
7	Pishica	1.9	867,666	9.1%
8	Selemli	2.2	1,982,921	10,49%
9	Grchishte	1.1	171,970	4.8%
10	Chaushliska	2.0	599,490	9.9%
11	Drazhevo	1.3	635,514	6.3%
12	Vasilevo-Dobrejci	3.4	4,717,212	15.4%
13	Konche	1.6	647,022	7.7%
14	K36	1.3	578,607	6.11%
15	Dabnichka reka	1.3	287,744	6.27%
16	Suvodolsko	2.9	3,250,059	12.6%
17	Gabalavci	1.4	1,073,584	6.8%
18	Desovo	2.0	952,462	9.6%
19	Tearce	1.2	229,483	5.3%
20	Banjichko pole	1.1	141,012	4.5%

Discount rate of 4% is used in the analysis which is considered to be representative social discount rate for Macedonia.

Based on the calculated project performance indices (B/C, ENPV and EIRR), it is concluded that the projects, if implemented under the presented assumptions, will result in significant increase of the local community welfare. This means that the total net project benefits for all preselected schemes over the analysed 25-year period of exploitation, have a total net present economic value of app. €18.2 million.

The study does not cover detailed analysis of the profit allocation; however, given the type of the projects, it is evident that minimum 80% of the stated ENPV belongs to the local communities – above all the farmers.

FINANCIAL COST-BENEFIT ANALYSIS

AIMS OF THE FINANCIAL ANALYSIS AND METHODOLOGY

The purpose of the financial analysis of costs and benefits of investment projects is three-fold:

- To assess the financial viability (financial cost-benefit) of the analysed project from the project implementing entities' point of view;
- To assess the affordability of the local community to bear the investment;
- To assess the financial sustainability of the project, i.e. the ability of the end-users to pay the prices/fees for the project services.

Corresponding to the economic analysis, the period which is subject to financial analysis is 25 years, of which the investment takes place during the first two years, while the project starts to generate revenues from the third year on.

The financial viability of the analysed projects is valued on the basis of two decision criteria, as follows:

- Financial Net Present Value (FNPV), and
- Financial Internal Rate of Return (FIRR).

Assumed discount rate used in the analysis is 4%. All project related costs incurred in the past are considered sunk costs, and therefore are not considered in the analysis. However, residual values of assets with an economic life beyond the analysed period have been considered. All costs, as in the financial analysis, are valued according to current prices in 2016. All calculations in this chapter are made in Euro, with exception of some tables where the results of the calculations are given in MKD. The financial analysis of the costs and benefits is based on the conclusion from the economic analysis.

PROJECT COSTS

The analysis takes into consideration the following categories of costs for each discussed alternative separately: (1) operation and maintenance costs (O&M); (2) electricity (water pumping) costs; (3) replacement costs; and (4) other costs. The project costs are annual costs required for continuous operation of the irrigation systems, including: labour costs, where applicable; maintenance of facilities and equipment; costs of replacement equipment and costs for consumed electricity.

Since the investment is planned to be fully granted, it is not taken as part of the project's costs.

Maintenance costs:

Maintenance costs for the construction part and maintenance costs for the equipment at all facilities of the system were analysed. The analysed categories of expenses, on an annual level, are projected as a percentage of the investment value for construction of the systems.

Labour costs:

Depending on the size of the systems, it is foreseen to have permanent employees for the continuous maintenance of the irrigation systems in the future. The following criteria was adopted. For the smaller systems of 200 hectares there is one permanent employee, while for the larger ones - two employees. This schedule of employees is in compliance with the current structure of employees in the existing water communities that manage the already constructed systems.

Electricity costs:

Electricity costs are applied to systems where water pumping is required to ensure the necessary working pressure in irrigation networks. Electricity consumption is a function of the required amount of water for irrigation, the pressure and the efficiency of the adopted pumped aggregates. Applied electricity price is pursuant to the tariff rate for industrial consumers, however, with projected growth rate it should reach the EU average price by 2018, when liberalization of the electricity market is expected. After this period, the price of electricity has a slower growth trend and follows the average projections of the EU countries.

Costs for replacement of the equipment:

They refer to the necessary re-investment in equipment (mainly pumping aggregates, automation of pumps, electrical equipment, equipment in filter stations, facilities of the irrigation network: standpipes, valves, seals, etc.) and installations that should be realized during the life cycle of the analysed project. As a result of the different periods of depreciation, the various pieces of equipment and buildings will be replaced at different times and with different frequency. Generally, during the observed 25-year period of exploitation, it is foreseen to perform replacement of the equipment of pump stations twice, and single replacement of the facilities of irrigation networks.

Other expenses:

As an additional cost of the systems, insurance of the equipment is taken. Insurance is calculated as a percentage of the total investment value of the project on annual basis (0,05%).

Also, if the irrigation scheme, as a source of water for irrigation uses water from another larger system (Water Management Enterprise - WME) as an additional cost, the price of water that farmers should pay to the WME is introduced. In the financial analysis, the price of this service is estimated at 0,5 MKD per cubic meter of used water.

TOTAL PROJECT COSTS

Distribution of all costs per irrigation schemes are shown on table below:

Table 2-16 Costs per irrigation scheme

	IRR Scheme	Electricity costs	Salaries	Maintenance costs	Replacement costs	Other costs	WME service	Av. annual O&M costs	Unit O&M costs (euro/ha)
1	Zajas	8,901	11,287	17,023	13,981	755	0	52,013	309
2	Kolibari	8,477	11,287	15,709	13,361	722	0	49,620	310
3	Slavishko pole	0	22,574	20,245	16,425	954	0	60,280	256
4	DJK	13,272	22,574	24,620	19,501	1,060	0	81,120	345
5	Konopnica	0	11,287	7,984	7,368	357	0	27,027	386
6	Mavrovica	0	22,574	30,494	13,083	1,510	16,778	84,570	302
7	Pishica	0	11,287	9,099	5,968	458	6,883	33,735	198
8	Selemli	43,170	22,574	17,100	12,389	763	0	96,062	444
9	Grchishte	35,517	11,287	27,361	9,671	717	0	84,615	564
10	Chaushliska	0	11,287	5,039	3,108	268	3,307	23,031	329
11	Drazhevo*	47,933	11,287	17,390	14,916	839	0	92,438	462
12	Vasilevo-Dobrejci	0	22,574	19,390	24,147	790	13,756	80,726	269
13	Konche	0	11,287	10,486	7,671	532	5,088	35,110	351
14	K36	16,093	22,574	18,705	11,775	910	11,009	81,144	312
15	Dabnichka reka	0	11,287	8,951	7,696	407	0	28,376	258
16	Suvodolsko	0	22,574	16,515	11,051	842	0	51,055	167
17	Gabalavci	0	22,574	24,090	11,708	1,199	12,694	72,370	266
18	Desovo	0	11,287	8,679	5,419	455	4,057	29,937	234
19	Tearce	0	11,287	13,880	11,415	608	0	37,243	232
20	Banjichko pole	0	11,287	20,609	13,067	941	0	45,985	264

*Data for the alternative with pumps are presented, because of the better economic parameters.

PROJECT REVENUES AND NET FINANCIAL BENEFITS

The fiscal (monetary) direct revenues from the project will accrue on the basis of payment of fees for the executed service, i.e. for provision of irrigation water with the required quality. Generally, when planning public infrastructure development projects with only one source of revenues based on fees for provided services, the total revenues should be balanced in order to enable full recovery of all associated costs – O&M, replacement and all other expenses – over the entire economic life of the project. Taking this aspect into consideration, for all analysed irrigation schemes in this analysis the projections of revenues are performed according to the following method:

Fee (unit price) is defined (determined), and this fee provides coverage of total operating (current) costs in the analysed period.

The definition of fees was conducted with a specially developed financial model. The model is constructed in a way that for the calculated value of the outflows (costs) it requires the necessary incomes to make the project viable, but without additional profit.

THIS CONDITION CAN BE EXPLAINED AS INCOMES THAT GENERATE ZERO NET PRESENT VALUE, OR WHERE THE RATIO OF EXPENSES AND BENEFITS IS EQUAL (FNPV=0, C/B=1), AT A DISCOUNT RATE OF 4,0%.

In other words, during the lifetime the project as much as it generates expenses it also generates revenues. After all input parameters are inserted into the model, it calculates the fee which covers all costs. The model also foresees continuous uniform growth of the fees by 2% annually, as well as gradual increase in the fee collection efficiency from initial 60% to a maximum of 90% for a period of 4 years.

The following tables present the required initial tariffs in €/m^3 (and consequently the average tariff rate during the reported period), for all preselected irrigation schemes.

Table 2-17 Tariffs to cover the total O&M cost of the system/project (den/m3)

	IRR Scheme	Start tariff	Average tariff
1	Zajas	3.9	5.0
2	Kolibari	3.9	5.0
3	Slavishko pole	3.4	4.4
4	DJK	4.9	6.2
5	Konopnica	5.5	7.0
6	Mavrovica	2.4	3.0
7	Pishica	2.3	2.9
8	Selemli	4.1	5.3
9	Grchishte	5.4	6.9
10	Chaushliska	3.3	4.2
11	Drazhevo	4.6	5.9
12	Vasilevo-Dobrejci	2.9	3.7
13	Konche	3.3	4.2
14	K36	3.5	4.5

15	Dabnichka reka	2.9	3.7
16	Suvodolsko	1.6	2.1
17	Gabalavci	2.7	3.4
18	Desovo	3.5	4.4
19	Tearce	3.2	4.1
20	Banjichko pole	3.6	4.7
	Average	3.5	4.5

Significant differences in tariffs can be noticed. Greater tariffs are conditioned primarily by the price for pumping water, in systems where it cannot be provided by gravity.

From the recent analysis and presentations, it can be noticed that the financial analysis is actually "Analysis of fees". In other words, the developed simulation model performs optimization analysis where by definition of the fees for the period considered, revenue that covers the costs of the project is generated, and this is based on previously conducted balance analysis that determines the quantities of consumed irrigation water.

The irrigation water fee that covers all O&M costs for all analysed irrigation schemes are in the range of 1.6 up to 5.5 den/m^3, i.e., the average water cost for all systems is 3,5 den/m^3.

The average price obtained for all systems is within the current prices of irrigation water in different regions provided by public water management organizations.

In order to assess the acceptability of water tariffs for irrigation by farmers, Socio-economic baseline survey will be conducted with the main objective of assessing the socio-economic conditions in the region, particularly regarding: composition of households; occupations; income; access to land and water for irrigation; perception about the project and affordability and willingness of the local farmers to pay increased fees for improved irrigation service. Socio-economic baseline survey will be carried out for the selected systems which will be further analysed in the final stage before the implementation.

3 SOCIAL ANALYSIS

The social analysis for each of the 20 locations was conducted based on two components:

1. Desktop research:
- Unofficial information that can be found about the location / village(s);
- Information extracted from the State Statistical Office, both for the villages as well as for the Municipality / region it belongs to.

This kind of data revealed the number, structure and density of the population, if inhabitants are migrating, what is the average salary, how many are receiving social care etc.

2. Discussion with the local citizens through the meetings with farmers:
- Information regarding the crops on the location - whether they are more interested into traditional or modern crop cultures, what is present now in terms of crops compared to before, what are the quantities that they make from the land that they have, if they are breeding cattle etc.;
- Information regarding the way the land is irrigated at the moment in general and on their personal plots – if they have modern or traditional systems, if they pay for the water and if they are using the services of the JSC for Water Management;
- What is the quality of life – how do local citizens live, how dependent are they on the agricultural activities, if they rely on the social care or they try to manage living on their own;
- Situation with migration – if people migrate, if there are young people in the village so that sustainability of agriculture is assured;
- The citizens also gave their perspective on the subject of the climate changes consequences – if they remember better times from the past, the amount of rain that is falling, the availability of water etc.

Special attention was dedicated to the subject of forming water communities, and in order to determine if there is willingness amongst the farmers to cooperate and manage it together. Here, the discussion revealed whether cooperation exists among the inhabitants in general, what is the level of interest and enthusiasm to go through the process so that their location gets the system. Also, background information was gathered on previous experiences and satisfaction with the existing / previous solutions.

The results from this analysis is presented as part of the Screening Report – farmers meetings, and in the Chapter 10: Social analysis, part of the Pre-feasibility study for each of the locations.

Table 3-1 Table of meetings with farmers

Number of meeting	Date	Irrigation Location Visited	Area
1	30.10.2017	Zajas 2	South-West
2	30.10.2017	Kolibari	South-West
3	31.10.2017	Slavishko Pole	North-East

4	31.10.2017	Konopnica	North-East
5	01.11.2017	Dam Mavrovica	East
6	01.11.2017	Dam Pishica	East
7	02.11.2017	Banjichko Pole	Polog
8	02.11.2017	Velmej	South-West
9	03.11.2017	Dovezance-Jacince-Klechovce	North-East
10	03.11.2017	Tearce	Polog
11	06.11.2017	Dam Konche 3 and 1	South-East
12	06.11.2017	Dabnicka reka	Vardar
13	06.11.2017	Podles	Vardar
14	08.11.2017	Suvodolsko	Pelagonija
15	08.11.2017	Desovo	Pelagonija
16	09.11.2017	Chaushliska Dam	South-East
17	09.11.2017	Drazhevo	South-East
18	09.11.2017	Vasilevo-Dobrejci	South-East
19	10.11.2017	Selemli	South-East
20	13.11.2017	Gabalavci	Pelagonija
21	14.11.2017	K36	Vardar
22	14.11.2017	Grchishte	South-East

Memorandum of Understanding (MoU):

In order to make sure that farmers from the 20 chosen locations are ready to also manage the system by participating in some sort of water community, the project developed Memorandum of Understanding (MoU). The aim was to have a confirmation that the farmers living there are really ready to form an entity through which they would manage the system, so that we can be sure that once the 6-8 locations are chosen, the process of forming those entities can start. The MoU was developed in English (for reviewing, included below) and Macedonian (for signing). It was agreed that the Head of the local community is the most appropriate person to sign the MoU in the name of the farmers. This was relatively easy to organize, as the farmers were already informed on the subject during the meetings, hence the Head of the local community was re-assured that this would not be a problem with the local inhabitants. In several locations, the Heads gathered with the farmers to discuss once more before signing, just to make sure everybody fully understands the project. Only in some cases where the Head of the local community was not able to sign (due to re-election as result of the local elections, illness or similar), some other representative signed (from the Municipality or from the local community). The process of signing the MoUs was in two ways, depending on how it was best for the representatives - in person or via post.

Mали, нискотрошковни, еколошки прифатливи системи за наводнување: избирање на локации и подготовка на целосно тендерско досие за изградба

EuropeAid/137393/DH/SER/MK

MEMORANDUM OF UNDERSTANDING

between

Irrigation scheme (location): ____,

and

The Project "Small-scale, low-cost, environment friendly irrigation schemes: sites selection and preparation of full work tender dossier" EuropeAid/137393/DH/SER/MK, funded by the EU.

The objective of this Memorandum of Understanding (MoU) is to express the willingness of both parties to engage in an effort to successfully implement The Project. This Memorandum, although not a legally binding document, indicates a voluntary agreement from both parties to assist in the implementation of project activities.

The Project started with the identification of possible sites, reaching a number of 20 possible locations. With further analysis it should be selected which 6-8 locations will enter the next phase of the project, with preparation of Feasibility studies, technical design, farmers groups formation, development of tariff Methodology, and future financing of construction works.

For all 20 locations, a representative of the Community, on behalf of more than 50% of the farmers on the potentially irrigated area, needs to confirm giving support to the project and, if chosen, taking over the management of the system once it is built.

With this MoU, the undersigning representative of the farmers confirms that more than 50% of the farmers on the potentially irrigated area are willing to support the project and take responsibilities to manage it in the future.

Specific activities under this MoU will be identified through consultation between the two parties, which will consist of (but not limited to) providing the necessary assistance to the selected locations, for capacity building of Communities, through trainings on Business plan implementation for the future Agriculture cooperatives and governance rules (i.e. internal operating rules for water use and planning and irrigation scheme management), execution of maintenance and servicing tasks, collection of fees, preparation of budgets, etc.

This MoU shall be operational upon signing by both parties and will have an initial duration of 6 months. For the selected locations it will be extended automatically until the project complition. The additional activities of this MoU will be regulated with an Annex.

The overall communication arising from this Memorandum will take place between the representatives of both parties.

Accordingly, the parties agree in the execution of this MoU on the ___/___/______.

On behalf of the Consortium:	Head of local community / representative/mayor:
Tatjana Todoroska, Project Director	Name and Surname, signature

Овој проект е финансиран од
Европската Унија

Овој проект е имплементиран од Ептиса, ПоинтПро и Темелсу
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E-mail: irrigationmk@eptisa.com

Figure 3-1 Memorandum of Understanding (English version)

Figure 3-2 Photos of some representatives signing the Memorandum of Understanding

4 POSSIBLE SITES FOR INVESTMENT

The complete list of the 20 sites studied at pre-feasibility level, with a summary of all data determined at this stage is shown in the following table:

Table 4-1 Summary of data for the 20 sites studied at Pre- Feasibility level

Pre-feasibility Study Nº	Region	Irrigation System name and Municipality	Design irrig.area	Actual irrig.area	Sp. agric. production	Specific variable cost	Specific fixed cost	Specific net profit	Total investment cost	Sp. total invest. cost	Total annual O&M cost	Specific ann. O&M cost	Av. ann. econ. benef.	Pr.value proj.benefits	Pr.value proj. Costs	Benefit/Cost Ratio	ENPV	EIRR	Initial Water Tariff	Average Water Tariff
			ha	ha	Mkd/ha	Mkd/ha	Mkd/ha	Mkd/ha	€	€/ha	€	€/ha	€			-	€	%	Mkd/m3	Mkd/m3
1	South-West	Zajas 2, Kichevo Municipality	168	30	176.406	129.418	12.662	34.326	1.303.622	7.760	51.947	309	73.493	1.878.000	1.499.159	1,25	378.841	6	3,90	5,00
2	South-West	Kolibari, Kichevo Municipality	160	100	176.406	129.418	12.662	34.326	1.246.838	7.793	49.557	310	74.787	1.940.348	1.424.533	1,36	515.815	6,31	3,90	5,00
3	North-East	Slavishko Pole, Rankovce Municipality	235	40	161.076	117.950	12.051	31.074	1.638.250	6.971	60.198	256	160.831	2.552.021	1.927.458	1,37	624.563	6,14	3,40	4,40
4	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Municipality	235	30	161.076	117.950	12.051	31.074	1.828.889	7.783	81.028	344	105.050	2.591.077	2.179.141	1,19	411.936	5,33	4,90	6,20
5	North-East	Konopnica, Kriva Palanka Municipality	70	0	220.885	165.336	16.349	39.200	611.226	8.732	26.996	386	40.439	995.545	766.586	1,30	228.959	6,08	5,50	7,00
6	East	Dam Mavrovica, Sveti Nikole Municipality	280	0	109.191	75.399	8.066	25.726	3.404.685	12.160	84.439	302	155.073	3.656.714	3.755.316	0,97	-98.602	3,80	2,40	3,00
7	East	Dam Pishica, Probishtip Municipality	170	70	153.131	111.128	11.327	30.676	794.540	4.676	33.493	198	72.484	1.859.476	991.810	1,90	867.666	9,14	2,30	3,00
8	South-East	Selemli, Bogdanci Municipality	216	200	291.372	220.164	20.495	50.714	1.335.442	6.183	95.996	444	136.447	3.630.868	1.647.948	2,20	1.982.921	10,49	4,10	5,30
9	South-East	Grchishte, Valandovo Municipality	150	150	249.709	182.123	18.219	49.363	1.274.215	8.459	84.553	564	105.202	2.122.600	1.950.630	1,10	171.970	4,85	5,40	6,90
10	South-East	Chaushica, Bosilovo Municipality	70	0	247.109	183.529	16.603	46.978	463.717	6.625	23.008	323	47.661	1.206.378	606.888	2,00	599.490	9,85	3,30	4,20
11	South-East	Drazhevo, Novo Selo Municipality, WELLS ALTERNATIVE	200	80	280.172	214.146	19.319	46.707	1.500.053	7.500	92.366	462	132.558	2.905.285	2.269.771	1,28	635.514	6,32	3,50	5,90
11	South-East	Drazhevo, Novo Selo Municipality, DAMS ALTERNATIVE	200	80	280.172	214.146	19.319	46.707	4.165.613	20.828	56.739	284	132.558	3.528.839	3.671.214	0,96	-142.375	3,75	2,80	4,60
12	South-East	Vasilevo-Dobrejci, Vasilevo Municipality	300	60	255.648	187.175	17.022	51.451	1.314.126	4.380	80.657	269	239.422	6.683.709	1.966.497	3,40	4.717.212	15,42	2,90	3,70
13	South-East	Dam Konche 3 and 1, Konche Municipality	100	20	305.047	229.877	22.113	53.057	916.017	9.160	35.064	351	68.213	1.738.340	1.091.318	1,60	647.022	7,66	3,30	4,20
14	Vardar	K36/Sopot, Kavadarci Municipality	260	370	225.851	153.057	16.313	56.480	1.584.019	6.092	81.065	312	107.432	2.545.503	1.966.895	1,29	578.607	6,11	3,50	4,50
15	Vardar	Dabnicka Reka, Kavadarci Municipality	100	60	225.851	153.057	16.313	56.480	697.402	6.340	28.341	258	45.452	1.138.031	850.287	1,34	287.744	6,27	2,90	3,71
16	Pelagonija	Suvodolsko, Novaci Municipality	305	150	176.792	125.445	11.947	39.400	1.459.132	4.784	50.982	167	174.260	4.921.416	1.671.357	2,90	3.250.059	12,61	1,60	2,10
17	Pelagonija	Galabavci, Bitola Municipality	272	1	182.101	132.441	12.902	36.758	2.078.715	7.642	32.226	266	140.450	3.504.416	2.430.881	1,40	1.073.584	6,82	2,70	3,40
18	Pelagonija	Desovo, Dolneni Municipality	128	120	196.150	136.512	12.658	46.980	788.746	6.162	29.897	234	71.458	1.886.797	934.335	2,00	952.462	9,58	3,50	4,40
19	Polog	Tearce, Tearce Municipality	160	30	159.620	119.547	11.457	28.616	1.042.831	6.158	37.190	232	57.864	1.453.296	1.233.813	1,19	229.483	5,29	3,20	4,10
20	Polog	Banjichko Pole, Gostivar Municipality	150	50	159.620	119.547	11.457	28.616	1.619.815	9.309	45.903	264	75.976	1.918.887	1.777.874	1,08	141.012	4,55	3,60	4,70

*Note: Two alternatives were studies for Drazhevo irrigation system. The dams alternative has a quite high total investment cost, therefore only the wells alternative was considered.

4.1 METHODOLOGY FOR RANKING

As a result of the economic and financial analysis, the following project performance indices were calculated:

Benefit / Cost ratio (BCR): is the relationship between the costs and benefits of a proposed project. It is calculated by dividing the total discounted value of the benefits by the total discounted value of the costs. If a project has a BCR that is greater than 1, it indicates that the NPV of the project benefits outweighs the NPV of the costs. Therefore, the project should be considered if the value is significantly greater than 1. If the BCR is equal to 1, the ratio indicates that the NPV of expected profits equal the costs. If a project's BCR is less than 1, the project's costs outweigh the benefits and it should not be considered.

Expected Net Present Value (ENPV): is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyse the profitability of a project. A positive net present value indicates that the projected earnings generated by a project or investment (in present dollars) exceeds the anticipated costs (also in present dollars). Generally, an investment with a positive NPV will be a profitable one, and one with a negative NPV will result in a net loss.

Expected Internal rate of return (EIRR) is the discount rate that makes the net present value (NPV) of all cash flows from a project equal to zero. The higher the project's internal rate of return, the more desirable it is to undertake the project. IRR is uniform for investments of varying types and, as such, IRR can be used to rank the irrigation projects on a relatively even basis. Assuming the costs of investment are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first.

Therefore, the simplest ranking methodology should be to rank all the projects according to the EIRR and choose the first 8 ones.

This will not take into account other criteria established by the ToR, for example, the equal distribution across the national territory.

There are also other criteria and constraints that can be taken in account such as:

Criteria:

- Number of farmers benefited by the project;
- Whether the locations are in areas affected by climate change or not;
- Whether they are part of /depending from a higher hydro-melioration scheme or independent;
- If they are under the current administration of a JSCWM or not;
- The cost per hectare – if it is low or high;
- If they have low or high specific agronomical production (mkd/ha), depending on the farm model / cropping pattern;

Constraints:

- Water availability;
- 100% community based, or with some private companies owning part of the irrigated area;
- Having market placement problems;
- Close to urban areas that can expand on the irrigated area in the future;
- Having high O&M cost, that will result in high water tariff (affordability for farmers).

The proposed methodology is:

1) To divide the project in 7 different areas: South-West, North-East, East, South-East, Vardar, Pelagonija, Polog. (in order to achieve equal distribution in the national territory);
2) Do the ranking of projects in each region according to a decreasing EIRR indicator;
3) Take into consideration the criteria and constraints for each project, according to the following weigh table:

Table 4-2 Weighs for each criteria and constraint

Nº farmers	**< 70**	**70< Nº farmer<150**	**>150**
	2	1	0
Climate change	Low	Medium	High
	2	1	0
Part of HHMS	Yes	No	
	1	0	
WMC administration	Yes	No	
	1	0	
Cost per hectare	>7500 €/ha	5000 <€/ha< 7500	< 5000 €/ha
	2	1	0
Specific agronomical production	<200 Mmkd/ha	250<Mmkd/ha<200	> 250 Mmkd/ha
	2	1	0
Water availability	Low	Medium	High
	2	1	0
Community based	No	Yes	
	1	0	
Marketing problems	Yes	No	
	1	0	
Close to urban areas	Yes	No	
	1	0	
Water tariff	> 4 mkd/m3	3<mkd/m3<4	<3 mkd/m3
	2	1	0

In the following table, the most important criteria and constraints for each project is summarized. Each criteria or project will be given a qualification of 1, 2 or 3, according to the expected negative influences in the future development of the area.

Table 4-3 Criteria and constraints for each project, with weight

Nº of Feasibility St.	1	2	3	4	5	6	7	8	9	10
Name of location	Zajas	Kolibari	Slavishko Pole	DJK	Konopnica	Dam Mavrovica	Dam Pishica	Selemli	Grchishte	Chaushliska
Nº farmers	>100, 1	>100, 1	250, 0	100, 1	200, 0	300, 0	75, 1	20, 2	300, 0	200, 0
Climate change	L, 2	L, 2	M, 1	M, 1	L, 2	M, 1	M, 1	H, 0	H, 0	M, 1
Part of HHMS	N, 0	N, 0	N, 0	N, 0	N, 0	Y, 1	N, 0	N, 0	N, 0	N, 0
WMC administration	N, 0	N, 0	N, 0	Y, 1	N, 0	Y, 1	Y, 1	N, 0	N, 0	N, 0
Cost per hectare	7760, 2	7793, 2	6971, 1	7783, 2	8732, 2	12160, 2	4676, 0	6183, 1	8459, 2	6625, 1
Specific agronomical production	176406, 2	176406, 2	161076, 2	161076, 2	220885, 1	109191, 2	153131, 2	291372, 0	249709, 1	247109, 1
Water availability	H, 0	M,1 depends on Zayas	H, 0	M,1 Depends on Slavishko Pole	L,2	H, 0	M,1	L,2 Possible conflict if Combinat is used in the future	H, 0	M, 1
Community based	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0 there is a company that was not included in the irrigated area, but can benefict from the project	N, 1 Agrolozer is owner of 40% of the irrigated area
Marketing problems				Y, 1						
Close to urban areas										
Water tariff	5, 2	5, 2	4,4 2	6,2 2	7 2	3 1	3 1	5,3 2	6,9 2	4,2 2

Nº of Feasibility St.	11	12	13	14	15	16	17	18	19	20
Name of location	Drazhevo	Vasilevo-Dobrejci	Dams Konche	K36/Sopot	Dabnicka Reka	Suvodolsko	Galabavci	Desovo	Tearce	Banjichko Pole
Nº farmers	100, 1	300, 0	70, 1	200, 0	100, 1	300, 0	60, 2	100, 1	160, 0	150, 0
Climate change	M, 1	M, 1	M, 1	M, 1	M, 1	L, 2	L, 2	L, 2	L, 2	L, 2
Part of HHMS	N, 0	Y, 1	N, 0	N, 0	N, 0	N, 0	Y, 1	N, 0	N, 0	N, 0
WMC administration	Y, 1	Y, 1	Y, 1	Y, 1	Y, 1	N, 0	Y, 1	Y, 1	N, 0	N, 0
Cost per hectare	7500, 1	4380, 0	9160, 2	6092, 1	6340, 1	4784, 0	7642, 2	6162, 1	6158, 1	9309, 2
Specific agronomical production	280172, 0	255648, 0	305047, 0	225851, 1	225851, 1	176792, 2	182101, 2	196150, 2	159620, 2	159620, 2
Water availability	H, 0	L,2 End user. Depends on upstream efficiency	M, 1	H, 0	M, 1	H, 0	H, 0	M, 1	M, 1	H, 0
Community based	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0	Y, 0
Marketing problems										Y, 1
Close to urban areas										Y, 1
Water tariff	5,9 2	3,7 1	4,2 2	4,5 2	3,71 1	2, 1	3,4 1	4,4 2	4,1 2	4,7 2

In the previous table, the value that corresponds to each criteria or constraint is provided, followed by the weigh.

For example, considering the number of farmers, in Zajas project, the number of farmers is more than 100, which has a weight of 1, and in Slavishko Pole there are 250, which has a weight of 0.

It is important to mention that the projects which have High water availability H, 0 are projects that can be studied at feasibility level for a bigger area that the one considered in the pre-feasibility study, in case there are no other constraints for such area expansion. This will allow to increase the investment cost, in case the Steering Committee wants to increase the expenditure in small irrigation projects to the total amount that corresponds to the selected projects.

SELECTION OF BEST PROJECT IN EACH REGION

To make a decision of which project to be selected in each area (plus one more to reach the number of 8), it is necessary to take into account both the criteria of the ToR and the criteria agreed with MAWFE. All projects comply the criteria, but the degree of compliance can vary from project to project. The weights considered for each criterion were added in the final column, however some criteria could have more relevance than others. Thus, the weights given to criteria and constraints should not be considered strictly according to the numeric value, but as a notice that a project can be of more interest than another, and due to this reason to be taken into consideration. For example, following the criteria and constraints, projects in each region are analysed and summarized as follows:

South-West	Both **Kolibari** and **Zajas** irrigation projects are very similar. • Kolibari is slightly better in the economic ratios than Zajas, but as it is located on the same river downstream Zajas, the water availability depends on the amount diverted by Zajas. • Both irrigation systems need a pump station, which means that the water tariff will be higher.
North East	**Slavishko Pole** and **Dovezence-Jachince-Klechovce** (DJK) are located on the same river. They must be studied hydrologically in parallel, but they do not belong to the same municipality, so according to the ToR and MAFWE, they cannot be jointed in one project. • **DJK** is located downstream Slavishko Pole, the water availability in DJK depending on the amount of water diverted by Slavishko Pole. • The advantage of **Slavishko Pole** is that there is no need to pump the water, which reduces the operation cost and leads to better economic indicators; • **DJK** need a pump station to provide pressurised irrigation water, which leads to higher costs and higher tariffs. • **Konopnica** has a very limited source of water, also used for water supply.
East	• The **Pishica** dam is being repaired with EU funds, but the irrigation system will not be rehabilitated. This means that the rehabilitation of the dam will increase the safety/prevention of floods to Pishica Village, but not benefit the agricultural production. This is a good reason to select Pishica irrigation system to be rehabilitated, but the water availability is not high; • **Mavrovica** needs the main pipeline of 8 km to be replaced, which leads to very high investment costs.
South East	In this region, the two projects with the best EIRR have relatively high constraints, and no one is clearly better. • **Vasilevo - Dobrejci** is the irrigation system with the best economic indicators but being the last user of the LHMS Vodocha dam means the water availability in this system is heavily dependent on the efficiency of water use by all previous users. That is a constraint to be taken into account, because it does not depend only on the water management inside the system; • The next better one, **Selemli**, is a dam that was constructed by a Combinat that is currently not using the land. If in the future the Combinat land is used, there will be not enough water for both systems: the one proposed now, and the one existing previously; • **Chaushica** dam has a small volume which irrigates a reduced area, which leads to reduced investment costs. Also, after the Pre-Feasiblity study it was found that the amount of water is not enough for one of the villages identified as beneficiary. Thus, 40% of the possible area for irrigation belongs to a private company which can be advantageous for the management of the system, but the ToR criteria states that community-based systems are preferred; • **Konche** has a limited amount of water available, which leads to reduced investment cost; • **Drazhevo** and **Grchishte** need pumping, which leads to lower economic indicators and higher tariff. The second one has a private owner which was not considered in the proposed irrigated area, although he can also benefit from the project.

Vardar	• **K36/Sopot** needs a pump station, which means that the water tariff will be higher compared to the systems with natural pressure; and depends on a LHMS for supply of water. • **Dabnichka Reka** has natural pressure but low water availability, which also means reduced irrigated area and reduced investment costs.
Pelagonija	• **Suvodolsko** irrigation system has natural pressure and high water availability. • **Desovo** has limited water availability, which leads to reduced irrigated area and reduced investment costs. • **Gabalavci** has a small number of farmers compared to other systems and depends on a LHMS for supply of water.
Polog	**Tearce** and **Banjichko Pole** are very similar. • Both locations need long main pipes that run across the village. Both locations have natural water pressure. • Tearce has a lower water availability than Banjichko Pole, while for the area of Banjichko Pole, having in mind the tendencies from last 20 years, there is a likelihood some percentage of the agricultural land to be transformed into an urban area, which is not valid for Tearce (due to the location it has) and has to solve marketing problems.

It is important to note that in the locations with zero risk in water availability, the irrigated area can be increased in the Feasibility Study, if there is no other constraint (available land, etc.). This could be a solution for utilization of the available funds, while on the other side, increasing the area chosen for the irrigation systems will increase the number of farmers who will benefit as end users.

Following the obtained ranking, based on the following criteria:

1) **Equal distribution across national territory:** at least one project of each region
2) **Higher Expected Internal Rate of Return (in each region)**,

the final projects considered by the Consultant as most preferable are:

South-West	**Kolibari** and **Zajas** could be considered as one location, but this will cause almost 3 million € to be located in only one location, reason for which this will be considered separately. **Kolibari** has slightly better indicators than Zayas, so is the first to be considered in this region.
North East	**Slavishko Pole,** not needing pumps, is more environmentally friendly and has better economic and financial performance than **Dovezence-Jachince-Klechovce** (DJK). As they are using the same river as source of water, they should be considered hydrologically as one project, but they belong to different municipalities. **DJK** in the point of view of the consultant has high social interest to be developed, because many are poor farmers even without water, although several plots that belong to people who does not reside in the location were identified. DJK is proposed to be considered as the second project in this region.
East	The **Pishica** dam is being repaired, thus it is good reason to provide a new irrigation system to use the rehabilitated infrastructure, but the water availability is not high.
South East	In this region, the two projects with best EIRR have relatively high constraints. The consultant suggests choosing the third one, **Chaushica** dam although 40% of the area belongs to a private company, which can be an advantage for the management of the system.

Vardar	In this region, both projects have some constraints: **K36/Sopot** depends on Tikvesh HMS and **Dabnichka reka** has low water availability. **K36/Sopot** is considered preferable for this region.
Pelagonija	In this region **Suvodolsko** irrigation system has natural pressure **and** high-water availability and the highest EIRR of all, therefore is considered the most preferable location.
Polog	Tearce and Banjichko Pole are very similar. Tearce has better economic indicators, and Banjichko Pole has more water available, urban proximity and marketing problems. **Tearce** is preferred, but **Banjichko Pole** is recommended as the second project for this area

There are three regions where two projects have been proposed in each region: Polog, North East and South East. The reason for proposing more than one project in a region is that is necessary to have some backup locations in case during the development of the Feasibility Studies, one of the locations has some constraint that suggest it is better to replace it by another.

PREFERABLE IRRIGATION SITES - RECOMMENDED FOR NEXT PHASE

Therefore, based on the above mentioned, the Consultant considers the following irrigation locations as preferable to be developed at Feasibility Level:

1) **Kolibari**
2) **Zajas**
3) **Slavishko Pole**
4) **Dovezence-Jachince-Klechovce**
5) **Pishica**
6) **Chaushica**
7) **K36/Sopot**
8) **Suvodolsko**
9) **Tearce**
10) **Banjichko Pole**

The ToR required 6 to 8 locations to be developed at Feasiblity level (1-8). In case some of the locations during Feasibility phase shows a high constraint that has not be identified during pre/feasibility study following two locations will enter into the 6-8locations.

LESS PREFERABLE SITES

The not recommended sites and the main reason for that are:

- **Konopnica**: too little water, in competition with water supply. Only 70ha for irrigation possible, in the best situation.
- **Mavrovica**: too high investment cost (3.4 Million € for 280 ha).
- **Vasilievo-Dobrejci**: last user of Vodocha dam. Depends on the efficient water use upstream.
- **Selemli**: future possible water conflict with the Combinat. Low number of farmers.
- **Konche**: little water available from different sources, just 100 potential hectares.
- **Drazhevo**: high pumping costs, high water tariff.
- **Grchiste**: high pumping costs, high water tariff. Water is now available at 6 m depth in every plot.

- **Dabnichka recka**: low water availability.
- **Gabalavci**: low number of farmers with bigger plots.
- **Desovo**: reduced wáter availablity, which will not be increased by the project (only by the increment in the water efficiencies. Farmers prefer dam option, which is too expensive for actual funding available.

Table 4-4 Table of preferable locations, recommended for proceeding into Feasibility Stage (8 locations plus 2 backup locations)

	Region	Irrigation System name and Municipality	Design irrigated area	Actual irrigated area	Total arable area	Nr farmers	Sp. agric. production	Specific variable cost	Specific fixed cost	Specific net profit	Total investment cost	Sp. total invest. cost	Total annual O&M cost	Specific ann. O&M cost	Av. ann. econ. benef.	Pr.value proj.benefits	Pr.value proj. Costs	Benefit/Cost Ratio	ENPV	EIRR	Initial Water Tariff	Average Water Tariff
			ha	ha	ha		Mkd/ha	Mkd/ha	Mkd/ha	Mkd/ha	€	€/ha	€	€/ha	€	€	€	-	€	%	Mkd/m3	Mkd/m3
1	South-West	Kolibari, Kichevo Municipality	160	100	524	100	176.406	129.418	12.662	34.326	1.246.838	7.793	49.557	310	74.787	1.940.348	1.424.533	1,36	515.815	6,31	3,90	5,00
2	South-West	Zajas 2, Kichevo Municipality	168	30	691	100	176.406	129.418	12.662	34.326	1.303.622	7.760	51.947	309	73.493	1.878.000	1.499.159	1,25	378.841	6	3,90	5,00
3	North-East	Slavishko Pole, Rankovce Municipality	235	40	1.060	250	161.076	117.950	12.051	31.074	1.638.250	6.971	60.198	256	160.831	2.552.021	1.927.458	1,37	624.563	6,14	3,40	4,40
4	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	235	30	2.592	100	161.076	117.950	12.051	31.074	1.828.889	7.783	81.028	344	105.050	2.591.077	2.179.141	1,19	411.936	5,33	4,90	6,20
5	East	Dam Pishica, Probishtip Municipality	170	70	641	75	153.131	111.128	11.327	30.676	794.540	4.676	33.493	198	72.484	1.859.476	991.810	1,90	867.666	9,14	2,30	3,00
6	South-East	Chaushliska, Bosilovo Municipality	70	0	980	200	247.109	183.529	16.603	46.978	463.717	6.625	23.008	323	47.661	1.206.378	606.888	2,00	599.490	9,85	3,30	4,20
7	Vardar	K36/Sopot, Kavadarci Municipality	260	40	1.785	200	225.851	153.057	16.313	56.480	1.584.019	6.092	81.065	312	107.432	2.545.503	1.966.895	1,29	578.607	6,11	3,50	4,50
8	Pelagonija	Suvodolsko, Novaci Municipality	305	150	1.867	300	176.792	125.445	11.947	39.400	1.459.132	4.784	50.982	167	174.260	4.921.416	1.671.357	2,90	3.250.059	12,61	1,60	2,10
9	Polog	Tearce, Tearce Municipality	160	30	1.061	160	159.620	119.547	11.457	28.616	1.042.831	6.158	37.190	232	57.864	1.453.296	1.233.813	1,19	229.483	5,29	3,20	4,10
10	Polog	Banjichko Pole, Gostivar Municipality	150	50	594	150	159.620	119.547	11.457	28.616	1.619.815	9.309	45.903	264	75.976	1.918.887	1.777.874	1,08	141.012	4,55	3,60	4,70

Relevant indicators chosen to measure the benefits of each location

Table 4-5 Table of less preferable locations, not recommended for entering into the Feasibility Stage

Nº	Region	Irrigation System name and Municipality	Design irrig.area	Actual irrig.area	Nr farmers	Sp. agric. production	Total investment cost	Benefit/Cost Ratio	ENPV	EIRR	Average Water Tariff	Main reason for exclusion
			ha	ha		Mkd/ha	€	-	€	%	Mkd/m3	
1	North-East	Konopnica, Kriva Palanka Municipality	70	0	200	220.885	611.226	1,30	228.959	6,08	7,00	too little water, in competition with water supply. Only 70 ha possible in the best situation.
2	East	Dam Mavrovica, Sveti Nikole Municipality	280	0	300	109.191	3.404.685	0,97	-98.602	3,80	3,00	too high investment cost
3	South-East	Vasilevo-Dobrejci, Vasilevo Municipality	300	60	300	255.648	1.314.126	3,40	4.717.212	15,42	3,70	last user of Vodocha dam. Depends on the efficient use upstream.
4	South-East	Selemli, Bogdanci Municipality	216	200	20	291.372	1.335.442	2,20	1.982.921	10,49	5,30	future water conflict with Combinat. Low number of farmers
5	South-East	Dam Konche 3 and 1, Konche Municipality	100	20	70	305.047	916.017	1,60	647.022	7,66	4,20	little water available from different sources, just 100 ha
6	South-East	Drazhevo, Novo Selo Municipality, WELLS ALTER.	200	80	100	280.172	1.500.053	1,28	635.514	6,32	5,90	high pumping costs, high water tariff. Farmers wants dams alterantive
7	South-East	Grchishte, Valandovo Municipality	150	150	300	249.709	1.274.215	1,10	171.970	4,85	6,90	high pumping costs, high water tariff. Water is now available at 6 m deph in every plot.
8	Vardar	Dabnicka Reka, Kavadarci Municipality	100	60	100	225.851	697.402	1,34	287.744	6,27	3,71	low water availability.
9	Pelagonija	Galabavci, Bitola Municipality	272	5	60	182.101	2.078.715	1,40	1.073.584	6,82	3,40	low number of farmers with bigger plots.
10	Pelagonija	Desovo, Dolneni Municipality	128	120	100	182.123	788.746	2,00	952.462	9,58	3,50	low water availability. Farmers wants dams alterantive

4.2 FINAL RECOMMENDATIONS

The ToR establishes the bases for recommendation of priority investment sites justified by:

5) **The type of technology** of irrigation infrastructure (low-cost and environmentally friendly);
6) **Strong willingness** of water users to cooperate in managing the scheme further expressed in MoU or notary statements of farmers group;
7) **Socio-economic and gender aspects** shall be considered as well;
8) The selection of priority investment sites will be also on the basis of **available funding of the investment under IPA II (in particular IPA II 2015**) and/or other funding options through IFI's, national budget, etc.

Selection of priority investment sites should be done based on importance of benefits of each location measured by relevant indicators.

The 10 locations recommended for preparation of feasibility study are going to be evaluated once more time with the same methodology used to rank the final 10 in order to prioritise its financialization. In this case, instead of the constraints (to eliminate the projects with more constraints), the ranking will be performed define the more preferable projects. The criteria to be used will be

- **Low cost**:
    - the specific total investment cost (€/ha) will reflect lowest investment needed.
    - The initial water tariff (MKD/m3) will reflect economic sustainability for farmers.
- **Environmental friendly**: all systems are pressurized piped systems to increase the conduction and applications efficiencies, thus protecting the water resource. Systems that will not require pumping will be preferred.
- **Strong willingness of farmers** will not be considered because the 20 projects evaluated at pre-feasibility level have high interest from farmers. Projects were farmers were not willing to participate were already cleared from the list.
- **Socio-economic and gender aspects:** in this case, B/C ratio, the increase of the irrigated area (from actual to designed) and the percentage of irrigated area design in the irrigation system related to the total arable area in the village or villages will be used as indicators. Gender aspects were not specifically considered, because even in locations with patriarchal surrounding women will surely benefit from the irrigation system as with the rise of the economic development, the independency and access to education.

Table 4-6 Weights for each criterion

Cost per hectare	>7500 €/ha	5000 - 7500 €/ha	< 5000 €/ha
	2	1	0
Initial water tariff	>2,5 mkd/m3	3,20 – 3,50 mkd/m3	<3,20 mkd/m3
	2	1	0
Environmental Friendly	Pumping	No pumping	
	1	0	
B/C ratio	<1,5	1,5 – 2	>2
	2	1	0
Increase of irrigated area	<250%	250-500%	>500%
	2	1	0

Percentage of irrigated area to total arable area	≤ 15%	15 - 25%	>25%
	2	1	0

According to the weight in points given to each criterion, the projects with lower scores will be the best ranked.

The application of this criteria leads to the results shown in table 4-7.

11) **Suvodolsko**
12) **Pishica**
13) **Chauslishka**
14) **Slavishko Pole**
15) **K36/Sopot**
16) **Tearce**
17) **Banjichko Pole**
18) **Kolibari**
19) **Zajas 2**
20) **Dovezence-Jachince-Klechovce (DJK),**

In order to determine the locations in order of priority with equal distribution in the territory, the following criteria was applied:

- Respect the order of the weight points obtained by each location
- Avoid choosing two locations of the same area. First the best location was to be chosen, then the second
    - The first five locations ranked belongs to different areas, there was no need to modify the order.
    - Sixth and seven (Tearce and Banjichko Pole) are in the same region (Polog). Kolibari and Zayas 2) are in the same region, Sothe - West. Both have the same weight according to the benefit criteria. Then, comparing the figures for both systems, Tearce has lower total and specific (per hectare) investment cost, operation and maintenance costs, which leads to better B/C ratio and lower water tariff. Tearce is ranked in sixth place, and then it is necessary to incorporated the following system from another area, thus the choosing must be performed between Kolibari and Zajas 2. Both have the same weight according to benefit criteria. Comparing both, Kolibari has less investment cost and similar benefits, which leads to a higher ratio Benefit/Cost. Kolibari will occupy the seven position,
    - As Banjichko Pole has more weigh in the benefit criteria, it will be the eiproject.
    - The last two locations will be left as alternatives in case during Feasibility Study some location has some important constraints not foreseen during pre-feasibilty phase. They are Zajas 2 and DJK. Comparing both, DJK has the highest total and specific (per hectare) investment cost, operation and maintenance costs, which leads to lower B/C ratio and higher water tariff. DJK is left in the lowest priority for funding of the preferable sites.

The locations in order of priority with equal distribution in the territory are:

9) **Suvodolsko**
10) **Pishica**
11) **Chaushliska**
12) **Slavishko Pole**
13) **K36/Sopot**
14) **Tearce**
15) **Kolibari**
16) **Banjichko Pole**

And in case during Feasibility Studies one of the previous ones is not Feasible, there are 2 backup locations identified:

a. **Zajas 2**
b. **Dovezence-Jachince-Klechovce (DJK),**

Table 4-7 Application of ranking criteria for prioritization of investment

	Region	Irrigation System name and Municipality	Specific investment cost €/ha		Initial Water Tariff mkd/m3		Environmetal friendly		Benefit/Cost ratio		Increase of irrigated area %		Irrigated/total arable area %		TOTAL
			€/ha	weight points	mkd/m3	weight points	[-]	weight points	[-]	weight points	%	weight points	%	weight points	weight points
1	Pelagonija	Suvodolsko, Novaci Municipality	4.784	0	1,60	0	No pump	0	2,90	0	103%	2	16%	1	**3,00**
2	East	Dam Pishica, Probishtip Municipality	4.676	0	2,30	0	No pump	0	1,90	1	143%	2	27%	0	**3,00**
3	South-East	Chaushliska, Bosilovo Municipality	6.625	1	3,30	1	No pump	0	2,00	1	700%	0	7%	2	**5,00**
4	North-East	Slavishko Pole, Rankovce Municipality	6.971	1	3,40	1	No pump	0	1,37	2	488%	1	23%	1	**6,00**
5	Vardar	K36/Sopot, Kavadarci Municipality	6.092	1	3,50	1	Pump	1	1,29	2	550%	0	15%	1	**6,00**
6	Polog	Tearce, Tearce Municipality	6.158	1	3,50	1	No pump	0	1,19	2	433%	1	15%	1	**6,00**
7	Polog	Banjichko Pole, Gostivar Municipality	9.309	2	3,20	0	No pump	0	1,08	2	200%	2	25%	0	**6,00**
8	South-West	Kolibari, Kichevo Municipality	7.793	2	3,90	2	Pump	1	1,36	2	60%	2	31%	0	**9,00**
9	South-West	Zajas 2, Kichevo Municipality	7.760	2	3,90	2	Pump	1	1,25	2	460%	1	23%	1	**9,00**
10	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	7.783	2	4,90	2	Pump	1	1,19	2	683%	0	9%	2	**9,00**

Table 4-8 Order of priority for investments with equal distribution

Priority with equal distribution	Region	Irrigation System name and Municipality	Design irrigated area	Actual irrigated area	Total arable area	Nr farmers	Sp. agric. production	Specific variable cost	Specific fixed cost	Specific net profit	Total investment cost	Sp. total invest. cost	Total annual O&M cost	Specific ann. O&M cost	Av. ann. econ. benef.	Pr.value proj.benefits	Pr.value proj. Costs	Benefit/Cost Ratio	ENPV	EIRR	Initial Water Tariff	Average Water Tariff
Nr			ha	ha	ha		Mkd/ha	Mkd/ha	Mkd/ha	Mkd/ha	€	€/ha	€	€/ha	€	€	€	-	€	%	Mkd/m3	Mkd/m3
1	Pelagonija	Suvodolsko, Novaci Municipality	305	150	1.867	300	176.792	125.445	11.947	39.400	1.459.132	4.784	50.982	167	174.260	4.921.416	1.671.357	2,90	3.250.059	12,61	1,60	2,10
2	East	Dam Pishica, Probishtip Municipality	170	70	641	75	153.131	111.128	11.327	30.676	794.540	4.676	33.493	198	72.484	1.859.476	991.810	1,90	867.666	9,14	2,30	3,00
3	South-East	Chaushliska, Bosilovo Municipality	70	0	980	200	247.109	183.529	16.603	46.978	463.717	6.625	23.008	323	47.661	1.206.378	606.888	2,00	599.490	9,85	3,30	4,20
4	North-East	Slavishko Pole, Rankovce Municipality	235	40	1.060	250	161.076	117.950	12.051	31.074	1.638.250	6.971	60.198	256	160.831	2.552.021	1.927.458	1,37	624.563	6,14	3,40	4,40
5	Vardar	K36/Sopot, Kavadarci Municipality	260	40	1.785	200	225.851	153.057	16.313	56.480	1.584.019	6.092	81.065	312	107.432	2.545.503	1.966.895	1,29	578.607	6,11	3,50	4,50
6	Polog	Tearce, Tearce Municipality	160	30	1.061	160	159.620	119.547	11.457	28.616	1.042.831	6.158	37.190	232	57.864	1.453.296	1.233.813	1,19	229.483	5,29	3,20	4,10
7	South-West	Kolibari, Kichevo Municipality	160	100	524	100	176.406	129.418	12.662	34.326	1.246.838	7.793	49.557	310	74.787	1.940.348	1.424.533	1,36	515.815	6,31	3,90	5,00
8a	Polog	Banjichko Pole, Gostivar Municipality	150	50	594	150	159.620	119.547	11.457	28.616	1.619.815	9.309	45.903	264	75.976	1.918.887	1.777.874	1,08	141.012	4,55	3,60	4,70
8b	South-West	Zajas 2, Kichevo Municipality	168	30	691	100	176.406	129.418	12.662	34.326	1.303.622	7.760	51.947	309	73.493	1.878.000	1.499.159	1,25	378.841	6	3,90	5,00
8c	North-East	HMS Dovezance-Jacince-Klechovce, Kumanovo Mun.	235	30	2.592	100	161.076	117.950	12.051	31.074	1.828.889	7.783	81.028	344	105.050	2.591.077	2.179.141	1,19	411.936	5,33	4,90	6,20

The foreseen sources of funding are:

3) INSTRUMENT FOR PRE-ACCESSION ASSISTANCE 2014-2020 (IPAII,2014): Regarding according to the ToR and the consultant perception based in the expenditure of the Budget of EU contribution, it is expected that the available funding for contracting will be:
    a. 2019: 3.000.000 €
    b. 2021: 3.000.000 €

4) NATIONAL BUDGET OF THE REPUBLIC OF MACEDONIA: according to the 2015-2025 Activities' plan of Directorate for Water Management of MAFWE, (MAFWE,2015) the available funding for public irrigation infrastructure to be contracted will be:
    c. 2020: 3.000.000 €
    d. 2022: 1.600.000 €

Based on these assumptions, the consultant is proposing the following calendar for funding:

Table 4-9 Timeline for funding

			Year contracting	2019	2020	2021	2022
			IPA II	3.000.000		3.000.000	
			MAFWE		3.000.000		1.600.000
			Tot.financ.€	3.000.000	3.000.000	3.000.000	1.600.000
	Region	Irrigation System name and Municipality	Tot.invest.€				
1	Pelagonija	Suvodolsko, Novaci Municipality	1.459.132		1.459.132		
2	East	Dam Pishica, Probishtip Municipality	794.540	794.540			
3	South-East	Chaushliska, Bosilovo Municipality	463.717	463.717			
4	North-East	Slavishko Pole, Rankovce Municipality	1.638.250	1.638.250			
5	Polog	Tearce, Tearce Municipality	1.042.831			1.042.831	
6	Vardar	K36/Sopot, Kavadarci Municipality	1.584.019		1.584.019		
7	South-West	Kolibari, Kichevo Municipality	1.246.838			1.246.838	
8a	Polog	Banjichko Pole, Gostivar Municipality	1.619.815				1.619.815
			9.849.142	2.896.507	3.043.151	2.289.669	1.619.815
			Acumulated	2.896.507	5.939.658	8.229.327	9.849.142

According to the 2015-2025 Activities' plan of Directorate for Water Management of MAFWE, there will be allocated funds for Suvodolsko irrigation system in 2020.

Taking this into consideration, the consultant recommends being financed within the 3 million € programmed under IPA II 2015 the three best projects, following Suvodolsko, which has funds allocated for the next year:

- Pishica 794.540 €
- Chaushliska 463.717 €
- Slavishko Pole 1.638,250 €

In the second year (2020) they should be contracted Suvodolsko (1.459.132 €) and Tearce (1.042.831 €), but the cost of these two systems (2.501.963 €) will be less than the available funds, so the consultant recommends to contract in 2020:

- Suvodolsko 1.459.132 €
- K36/Sopot 1.584.019 €

Which sum up to 3.043.151€, matching the available funding.

In the third year (2021) they should be contracted Tearce (1.042.831 €) and Kolibari (1.246.838 €), which amount togheter 2.289.669, less than the 3 million available, but the 710.331€ remaining will not be enough for the last project Banjichko Pole, 1.619.815 €, that will have to wait until 2022 to be contracted.

4.3 Assessment of the beneficial Impacts

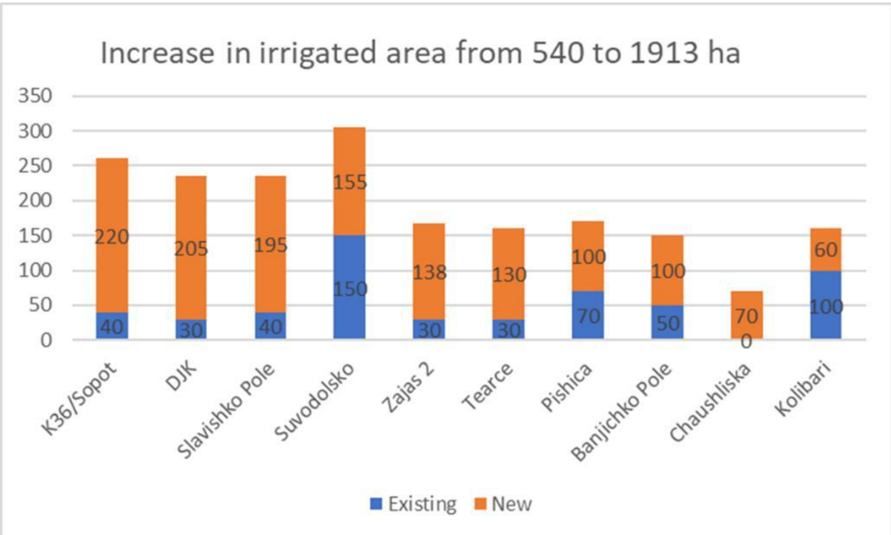
It is expected that the benefits of construction of small scale irrigation systems will make a significant contribution in reducing rural poverty by creating employment and improving livelihoods.

With access to water for irrigation incomes of those farmers with access to irrigated land will increase. Water control in agriculture may boost productivity and incomes by:

- ensuring adequate water throughout the growing season, contributing to higher yields and quality (higher farm-gate prices) by eliminating water deficits and providing at least a measure of drought protection;
- securing a crop where rainfall is inadequate or too variable;
- allowing a second or even a third crop by making water available in the dry season;
- allowing new crops or varieties for which market opportunities exist;
- improving timeliness and/or crop duration, allowing area expansion and/or increased cropping intensities;
- enabling farmers to adapt timing of production to market demand and higher prices, to take advantage of good weather conditions, or to avoid adverse weather extremes;
- reducing risk and raising returns in the use of complementary inputs such as improved seed and fertilizer;

With construction of particular locations, and based on findings from our pre-feasibility studies, we are expecting following beneficial impacts:

- Project will significantly increase the irrigated area, which is one of the strategy of the Ministry of Agriculture.

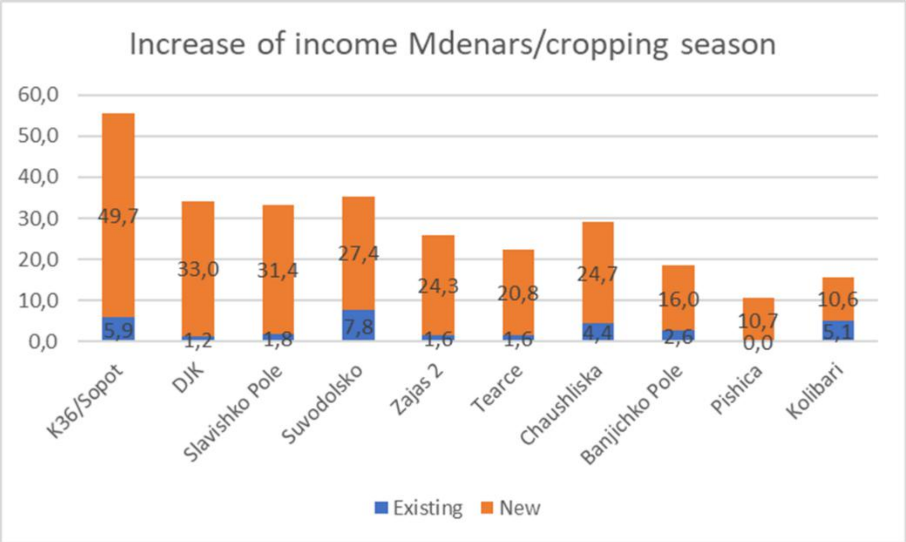


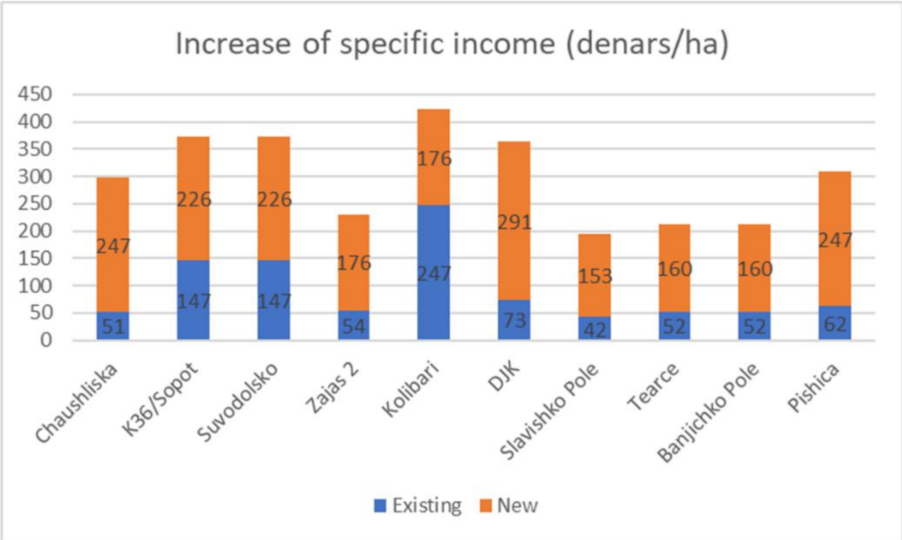
Benefits from the investment will ultimately be expressed as improved incomes within the target area. Access to water will also allow intensification of production and diversification into other higher valued crops.

The water user groups to be established, it is expected to operate more effectively and the collection of water user charges will provide the sustainability of the investment.

Furthermore the associate project activities will support farmers groups in their production and marketing of products. Benefits will be applied to all participants including the poor and vulnerable while the gender issue will be duly considered.

Graphics below are showing benefits from the increased income for selected locations:





More detailed information about the impacts will be available after the finalization of Feasibility Studies.

5 Annexes

5.1 Zajas 2

This annex is provided as a separate document.

5.2 Kolibari

This annex is provided as a separate document.

5.3 Slavishko Pole

This annex is provided as a separate document.

5.4 Dovezence-Jachince-Klechovce

This annex is provided as a separate document.

5.5 Konopnica

This annex is provided as a separate document.

5.6 Mavrovica

This annex is provided as a separate document.

5.7 Pishica

This annex is provided as a separate document.

5.8 Selemli

This annex is provided as a separate document.

5.9 Grchishte

This annex is provided as a separate document.

5.10 Chaushliska

This annex is provided as a separate document.

5.11 Drazhevo

This annex is provided as a separate document.

5.12 Vasilevo-Dobrejci

This annex is provided as a separate document.

5.13 KONCHE 3 AND 1

This annex is provided as a separate document.

5.14 K36

This annex is provided as a separate document.

5.15 DABNICHKA REKA

This annex is provided as a separate document.

5.16 SUVODOLSKO

This annex is provided as a separate document.

5.17 GABALAVCI

This annex is provided as a separate document.

5.18 DESOVO

This annex is provided as a separate document.

5.19 TEARCE

This annex is provided as a separate document.

5.20 BANJICHKO POLE

This annex is provided as a separate document.

5.21 ENVIRONMENTAL AREAS OF EVALUATION

For evaluating environmental impacts, each of the 53 following questions have been evaluated, and it is presented in the Result sheet as Chapter 6:" Preliminary Environmental Assessment" in every Pre-Feasibility study for each location.

1. Hydrological changes
   1.1. Low flow regime

   Is the low flow regime of the river substantially changed by the Project and its dams (by more than ±20% in low flow periods)? If so, does this change benefit or impair aquatic ecosystems, existing or potential downstream abstractions, hydropower, navigation or recreational uses?

   1.2. Flood regime

   Is the flood regime of the river (peak discharge and stage, speed of flood waves, flood super-position with joining rivers, duration or extent of floodplain inundations downstream) substantially changed by the Project as a result of changes in abstractions, retention storage, reservoir releases, flood protection works, new road/rail routes, river training or surface drainage works? If so, does this change benefit or impair aquatic and flood-affected ecosystems, lead to an increase or decrease in flood damage or change land use restrictions outside the Project?

1.3. Operation of dams

Can modifications to the operation of any storage or flood retention reservoir(s) compensate for any adverse impacts associated with changes in flow regime, whilst minimising the losses to the Project and other users? Possible modifications affecting water quality downstream, saline intrusion, the sediment regime of channels, the ecology of affected areas, amenity values, disease transmission or aquatic weed growth-should be considered.

1.4. Fall of water table

Does the Project cause a fall of the water table (from groundwater abstractions, reduced infiltration due to river training, drainage or flood protection works)? If so, does this fall lead to increased potential for groundwater recharge (from seasonal rainfall) and improved conditions for land use; or lead to depletion of the groundwater system, affecting wells, springs, river flows and wetlands?

1.5. Rise of water table

Does the Project cause a rise of the water table (from increased infiltration or seepage from irrigation, seepage from reservoirs and canals, or increased floodplain inundation)? If so, does this rise lead to improved yield of wells and springs and improved capillary rise into the root zone; or lead to waterlogging of agricultural or other land in the Project area or vicinity?

2. Organic and inorganic pollution

2.1. Solute dispersion

Are the Project and its dams leading to changes in the concentrations of organic or inorganic solutes in the surface water due to changes to the pattern of water abstraction and reuse in the basin or flow regulation? If so, do the changes benefit or impair biological communities ·or domestic, agricultural or industrial water users in the basin?

2.2. Toxic substances

Are significant levels of toxic substances accumulating or being introduced, mobilised and transmitted due to the construction and operation of the Project and its dams, or are levels being reduced? Substances such as pesticides, herbicides, hydrogen sulphide, oil derivatives, boron, selenium and heavy metals in irrigation supplies or surface, drainage and ground waters should be considered.

2.3. Organic pollution

Are nutrients, organic compounds and pathogens being reduced or introduced and concentrated, due to the Project, its dams and its associated domestic settlements? If so, does the change result in a reduction or increase in environmental and water use problems in the Project area or downstream (in rivers, canals, reservoirs, end lakes, evaporation wet lands, depressions, deltas, estuary regions) or in the groundwater?

2.4. Anaerobic effects

Is the Project reducing or creating anaerobic conditions or eutrophication in any impoundments, natural lakes, pools or wetlands due to changed input or accumulation of fertilisers, other nutrients and organic matter or due to changed water quality resulting from dams, river abstractions and drainage flows?

2.5. Gas emissions

Is the Project, either directly or through associated industrial processing, causing decreased or increased gas emissions which contribute to air pollution {0_3, $S0_3$, H_2S, NOx, NH_4, etc) or the greenhouse effect {$C0_2$, CH_4, NOx, etc.)?

3. Soil properties and salinity effects

3.1. Soil salinity

Is the Project leading to progressive accumulation of salts in the soils of the project area or the vicinity because of prevailing high salt content in, the soil, the groundwater, or the surface water; or can a progressive leaching effect be expected?

3.2. Soil properties

Is the Project leading to changes in soil characteristics within the Project area or the vicinity due to such activities as irrigation, the application of fertilisers or other chemicals, cultivation practices or dewatering through drainage? Changes which can improve or impair soil structure, workability, permeability, fertility associated with nutrient changes, humus content, pH, acid sulphate or hard pan formation or available water capacity should be considered.

3.3. Saline groundwater

Are changes to the rates of seepage, percolation or leaching from the Project and its dams increasing or decreasing the concentrations of chlorides, nitrates or other salts in the groundwater?

3.4. Saline drainage

Are changes to the concentrations of chlorides, nitrates or other salts in the runoff or drainage water from the Project area in danger of affecting biological communities or existing or potential downstream users (particularly during low flow conditions)?

3.5. Saline intrusion

Are the Project and its dams leading to changes in saline water (sea water) intrusion into the estuary or into groundwater due to changes in low flow, groundwater use, dredging or river training? If so, are the changes likely to affect biological communities and water users in the Project vicinity and other areas?

4. Erosion and sedimentation

4.1. Local erosion

Is increased or decreased soil loss or gully erosion being caused within or close to the Project area by changes in land gradient and vegetative cover, by irrigation and cultivation practice, from banks of canals, roads and dams, from areas of cut and fill or due to storm drainage provision?

4.2. Hinterland effect

Are the Project and its dams leading to changes in natural vegetation, land productivity and erosion through changes in population density, animal husbandry, dryland farming practices, forest cover, soil conservation measures, infrastructure development and economic activities in the upper catchment and in the region surrounding the Project?

4.3. River morphology

Is the regime of the river(s) changed by the Project and its dams through changes in the quantity or seasonal distribution of flows and flood peaks in the river(s), the abstraction of clear water, changes in sediment yield (caused by 4.1 and 4.2), the trapping of sediment in reservoirs or the flushing of sediment control structures? If so, do these changes benefit or impair aquatic ecosystems or existing or potential users downstream?

4.4. Channel structures

Is scouring, aggradation or bank erosion in the river(s), endangering the Project's river headworks, offtake structures, weirs or pump inlets, its canal network, drainage or flood protection works, the free flow of its drainage system or structures and developments downstream? Consider effects associated with changes noted in 4.3 as well as those caused by other existing and planned upstream developments.

4.5. Sedimentation

Are the changes noted in 4.1 - 4.4 causing increased or decreased sediment deposition in irrigation or drainage canals, hydraulic structures, storage reservoirs or on cultivated land, either via the irrigation system or the river(s)? If so, do these changes benefit or impair soil fertility, project operation, land cultivation or the capacity and operation of reservoirs?

4.6. Estuary erosion

Are the Project and its dams leading to changes in the hydrological or sediment regimes of the river which can affect delta formation or estuary and coastal erosion? If so, do these changes benefit or impair aquatic ecosystems (estuarine or marine), local habitation, navigation or other uses of the estuary?

5. Biological and ecological changes

Is the Project, its dams or its associated infrastructure causing substantial and permanent changes (positive or negative) within the habitats listed in 5.1 - 5.5?

- in the natural ecology (habitat, vegetation, terrestrial animals, birds, fish and other aquatic animals and plants),
- in areas of special scientific interest, or
- in biological diversity

Include the likely ecological benefit of any new or modified habitats created and of any protective or mitigatory measures adopted (such as nature reserves and compensatory forests).

5.1. Project lands: the lands within the project area.
5.2. Water bodies: newly created, altered or natural channels, reservoirs, lakes and rivers.
5.3. Surrounding area: all terrestrial areas influenced by the Project works and its associated domestic settlements and hinterland effects.
5.4. Valleys and shores: river and canal banks, lake, reservoir and sea shores and the offshore marine environment.
5.5. Wetlands and plains: floodplains or permanent wetlands including deltas and coastal swamps.
5.6. Rare species: Is the existence of any rare, endangered or protected species in the region enhanced or threatened by the changes noted in 5.1 - 5.5? Animal migration: endangered or protected species in the region enhanced or threatened by the changes noted
5.7. Animal migration: Does the Project, its dams or new road/rail routes affect the migration patterns of wild animals, birds or fish? Make allowance for the compensatory effect of any additional provision within the Project (canal crossings, fish passes, spawning locations, resting or watering places, shade, considerate operation).
5.8. Natural industry: Are commercial or subsistence activities depending on the natural terrestrial and aquatic environment benefited or adversely affected by the Project through ecological changes or changes in human access? Changes affecting such activities as fisheries, harvesting from natural vegetation, timber, game hunting. or viewing and honey production should be considered.

6. Socio-economic impacts

6.1. Population change

Is the Project causing significant demographic changes in the Project area or vicinity, which may affect social harmony? Changes to population size/density and demographic/ethnic composition should be considered.

6.2. Income and amenity

Is the Project introducing significant economic/political changes which can increase or decrease social harmony and individual well-being? Changes, in the general levels of employment and income, in the provision of local infrastructure and amenities, in the relative distribution of income, property values and Project benefits (including access to irrigation water) and in the demand for labour and skills (particularly in relation to family/political hierarchy and different sexes and social groups) should be considered.

6.3. Human migration

Has adequate provision been made for any temporary or migratory population influx to avoid social deprivation, hardship or conflicts within these groups or between the permanent and temporary groups? Human migration arising both from the demand for skills/labour during construction and from the requirements for seasonal agricultural labour should be considered.

6.4. Resettlement

Has adequate provision been made for the resettlement, livelihood and integration of any people displaced by the Project and its dams or losing land, grazing or other means of income due to the Project? Also, has adequate provision been made for the subsistence farming needs of people settled on or associated with the Project?

6.5. Women's role

Does the Project change the status and role of women (positively or negatively) in relation to social standing, work load, access to income and heritage and marital rights?

6.6. Minority groups

Are the Project and its dams causing changes to the lifestyle, livelihoods or habitation of any social groups (particularly minority groups) leading to major conflicts with, or changes to their traditional behaviour, social organisation or cultural and religious practices?

6.7. Sites of value

Is access improved or hampered to places of aesthetic and scenic beauty, sites of historical and religious significance or mineral and palaeontological resources? Also, are any such sites being destroyed by the Project?

6.8. Regional effects

Are the economic, infrastructural, social and demographic changes associated with the Project likely to enhance, restrict or lead to unbalanced regional development? Also, has adequate provision been made for new transport, marketing and processing needs associated with the Project?

6.9. User involvement

Has there been adequate user and public participation in project planning, implementation and operation to ensure Project success and reduce future conflicts? The potential for incorporating within the Project existing systems of land tenure, traditional irrigation, and existing organisational and sociological structures and for the provision of new or extended facilities for credit, marketing, agricultural extension and training should be considered.

6.10. Recreation

Are the Project and its dams creating new recreational possibilities (fishing, hunting, sailing, canoeing, swimming, scenic walks, etc) and are existing facilities impaired, preserved or improved?

7. Human Health

Consider each of the items 7.1 - 7.9 in relation to the local population, the labour force during construction and their camp followers, the resettled and newly settled populations and migratory labour groups.

7.1. Water and Sanitation

Are the provisions for domestic water, sanitation and refuse disposal such that oral, faecal, water washed, and other diseases and the pollution of domestic water can be controlled?

7.2. Habitation

Are the provisions for housing and forecast population densities such that diseases related to habitation or location of dwellings can be controlled?

7.3. Health services

Are general health provisions adequate (treatment, vaccination, health education, family planning and other health facilities)?

7.4. Nutrition

Is the Project leading to an increase or decrease in the general nutritional status of the population or to changes in other lifestyle or income related diseases? If so, are any specific groups particularly exposed to such health risks?

7.5. Relocation effect

Are population movements introducing new infectious or water-related diseases to the Project area or causing stress-related health problems or bringing people with a low resistance to particular diseases into areas of high transmission?

7.6. Disease ecology

Are the extent and seasonal character of reservoirs, canals, drains, fast flowing waters, paddy fields, flooded areas or swamps and the closeness or contact of the population with such water bodies leading to significant changes in the transmission of water related diseases?

7.7. Disease host

Are the populations of intermediate and other primary hosts of parasitic and water-related diseases (rodents, birds, monkeys, fish, domestic animals) and the interaction of the human population with these hosts, decreased or increased by the Project?

7.8. Disease control

Can the transmission of the diseases identified in 7.1, 7.2, 7.5, 7.6 and 7.7 be reduced by introducing into the Project environmental modifications or manipulations or by any other sustainable control methods? Possible environmental measures include both removal of breeding, resting and hiding places of vectors and reducing contamination by and contact with humans.

7.9. Other hazards

Is the risk to the population decreased or increased with respect to:

- pathogens or toxic chemicals present in irrigation water (particularly through wastewater reuse) or in the soils, which can accumulate in food crops or directly threaten the health of the population;
- dwellings adequately located and designed to withstand any storm, earthquake or flood hazards;
- sudden surges in river flow caused by the operation of spillways or power turbines; and
- structures and water bodies designed to minimise accident and allow escape?

8. Ecological imbalances

8.1. Pests and weeds

Are crop pests or weeds likely to increase or decrease (particularly those favoured by irrigation/drainage/flood control) affecting yields, cultivation and requirements for pesticides or herbicides?

8.2. Animal diseases

Are domestic animals in the Project or vicinity more or less exposed to hazards, diseases and parasites as a result of the Project and its dams?

8.3. Aquatic weeds

Are reservoirs, rivers or irrigation and drainage canals likely to support aquatic vegetation or algae? If so, can these plants be harvested or controlled, or will they reduce the storage/conveyance capacity, interfere with the operation of hydraulic structures or lead to oxygen-oversaturated or anaerobic water bodies?

8.4. Structural damage

Is there a danger of significant damage being caused to dams, embankments, canal banks or other components of the irrigation/drainage/flood control works through the action?

8.5. Animal imbalances

Does the Project cause zoological imbalances (insects, rodents, birds and other wild animals) through habitat modification, additional food supply and shelter, extermination of predators, reduced competition or increased diseases of plants and animals (including rodents and termites) favoured by the Project?

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